

Cost and Economic Assessment of
Alternative National Ambient Air Quality
Standards for Carbon Monoxide (Revised)

GCA Corp., Chapel Hill, NC

Prepared for

Environmental Protection Agency
Research Triangle Park, NC

Jul 85



U.S. Department of Commerce
National Technical Information Service

NTIS

TECHNICAL REPORT DATA (Please read Instructions on the reverse before completing)		
1. REPORT NO. EPA-450/5-85-006	2.	3. RECIPIENT'S ACCESSION NO. PB8 6 1057727AS
4. TITLE AND SUBTITLE Cost and Economic Assessment of Alternative National Ambient Air Quality Standards for Carbon Monoxide (Revised)	5. REPORT DATE July 1985	
	6. PERFORMING ORGANIZATION CODE GCA/Technology	
7. AUTHOR(S) Mark Smith, Susan Schechter, and Thomas McCurdy	8. PERFORMING ORGANIZATION REPORT NO.	
9. PERFORMING ORGANIZATION NAME AND ADDRESS GCA/Technology Chapel Hill, NC Energy and Environmental Analysis, Inc. Arlington, VA.	10. PROGRAM ELEMENT NO.	
	11. CONTRACT/GRANT NO. 68-02-3804	
12. SPONSORING AGENCY NAME AND ADDRESS Office of Air Quality Planning and Standards Office of Air and Radiation U.S. Environmental Protection Agency Research Triangle Park, N.C. 27711	13. TYPE OF REPORT AND PERIOD COVERED Final	
	14. SPONSORING AGENCY CODE	
15. SUPPLEMENTARY NOTES		
16. ABSTRACT The report presents cost and economic impact information needed to undertake a complete benefits/cost analysis of setting alternative carbon monoxide NAAQS. Four alternative 8-hour NAAQS were analyzed: 9 ppm, one observed exceedance, and 9,12,15 ppm one expected exceedance of daily maxima. The cost estimates are for both total societal and industrial sector control technology installation and operation. These include capital changes, annualized capital expenditures, and annual operating and maintenance/repair costs. Mobile source expenditures are analyzed separately from stationary source control costs. The economic impact analysis includes data on industry's ability to bear the capital expense and the inflationary and competitive impacts of incurring the control costs. Three time periods of analysis are used: 1987, 1990, and 1995.		
17. KEY WORDS AND DOCUMENT ANALYSIS		
a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air Pollution Carbon Monoxide	Air Quality Standards Cost Analysis Economic Analysis Control Techniques	
18. DISTRIBUTION STATEMENT Release to Public	19. SECURITY CLASS (This Report) Unclassified	21. NO. OF PAGES 166
	20. SECURITY CLASS (This page) Unclassified	22. PRICE 16.95

United States
Environmental Protection
Agency

Office of Air Quality
Planning and Standards
Research Triangle Park NC 27711

EPA-450/5-85-006
July 1985

Air

PB86-105772



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REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

EPA-450/5-85-006

**Cost and Economic Assessment of
Alternative National Ambient Air Quality
Standards for Carbon Monoxide
(Revised)**

U.S. ENVIRONMENTAL PROTECTION AGENCY
Strategies and Air Standards Division
Office of Air Quality Planning and Standards
Research Triangle Park, NC 27711

July 1985

ACKNOWLEDGEMENTS AND DISCLAIMER

Early versions of this report were prepared by Energy and Environmental Analysis, Inc. The firm's staff who were responsible for the report were Susan E. Schechter and Bruce Henning. EPA project managers were Allen Basala, Economic Analysis Branch, and Thomas McCurdy, Ambient Standards Branch.

That version was rewritten in part by EPA in 1982 based on new analyses made under Mr. McCurdy's direction. The current report is the result of extensive revisions by Mr. McCurdy and GCA/Technology Division in 1985. The work was performed under EPA Contract No. 68-02-3804. Key GCA staff members were Mark G. Smith, Mark W. Deese, and Nancy K. Browne. Questions regarding this report should be addressed to Tom McCurdy at MD-12, U.S. EPA, Research Triangle Park, N.C., 27711; (919) 541-5655 (FTS 629-5655).

This report has been reviewed by the Office of Air Quality Planning and Standards, U.S. EPA, and approved for publication. Mention of trade names or commercial products is not intended to constitute endorsement or recommendation for use.

PREFACE

In accordance with the provisions of Sections 108 and 109 of the Clean Air Act as amended, the Environmental Protection Agency has conducted a review of the criteria upon which the existing primary and secondary carbon monoxide standard are based. The Act specifically requires that National Ambient Air Quality Standards be based solely on scientific criteria relating to the level that should be attained to adequately protect public health and welfare. Based on the wording of the Act and its legislative history, EPA interprets the Act as excluding any consideration of the costs of achieving those standards or the existence of technology to bring about the needed reductions in emissions. However, in compliance with the requirements of various Executive Orders and OMB Circular A-107, EPA has prepared an assessment of the potential cost and economic impacts associated with efforts to attain alternative levels of the standard. This document presents the results of this assessment.

The assessment also provides the cost information needed for a complete benefits/cost analysis, as required by Executive Order 12291. This report does not meet the requirements of that Executive Order, nor is it intended to. A Regulatory Impact Analysis will be published under separate cover that meets the 12291 requirements.

The purpose of the analysis contained herein is to estimate the relative ranges of national control costs for alternative levels of the carbon monoxide standard. In addition, in order to compare the relative implications of alternative standards, the estimated number of urbanized areas which might be expected to attain the alternative standards given various assumptions is also indicated. Because of many uncertainties involved in projecting carbon monoxide emission levels and air quality and in determining effective control strategies throughout the nation, results of the analysis should be viewed only as being an indication of relative differences in attainment status and control costs for alternative standard levels. The analysis cannot be used to determine how many or which specific urbanized areas will attain a given

carbon monoxide standard through particular control strategies. Rather, attainment status and control requirements for attainment will have to be determined by the States for each geographical area, considering the unique conditions inherent to that area. Likewise, this analysis cannot estimate with certainty the national costs of control strategies needed for all areas of the country to attain alternative standards. Actual control costs will be extremely variable, and this analysis is only useful in presenting relative cost implications for alternative levels of the standard.

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1. SCOPE AND PURPOSE

The Clean Air Act, as amended in 1977, requires periodic review of ambient air quality standards. This study, which reviews the National Ambient Air Quality Standard (NAAQS) for carbon monoxide, analyzes 1) the hypothetical relative impacts that alternative changes in the standard would have on national costs of control and on attainment status for various areas of the country, and 2) the potential socioeconomic impacts of these costs.

This section presents the study's background, scope, and organization.

1.1 REGULATORY CONTEXT

Executive Order 12291, "Federal Regulation," requires among other things that all major rules be accompanied by a comprehensive analysis of cost and economic impacts of the federal rule or regulation. This cost and economic assessment is intended to meet the Executive Order requirement on the cost side. The Order also requires that a benefits analysis be undertaken for major rules, but CO NAAQS benefits are not discussed in this report. They are analyzed in a formal Regulatory Impact Analysis (EPA 1985) sent to the President's Office of Management and Budget, which includes excerpts from this report as well.

It should be noted that the Clean Air Act specifically requires that a NAAQS be established based on scientific criteria relating to the level that should be attained to protect public health with an adequate margin of safety. The Act precludes consideration of the cost or feasibility of achieving primary standards in determining the level of ambient standards. This policy has been affirmed by the U.S. District of Columbia Court of Appeals in *Lead Industries Association v. Environmental Protection Agency* (647 F.2d 1130 [1980]; cert. denied 449 U.S. 1042 [1980]).

At the present time there are two NAAQS's for carbon monoxide: an eight-hour standard of 9 parts per million (ppm), and a one-hour standard of 35 ppm. Both standards are not to be exceeded more than once each year. Only the costs and impacts of the eight-hour standards are addressed in this study because extensive examination of the one-hour issue indicates that, in all cases, both the current and alternative one-hour standards impose less stringent control requirements on both stationary and mobile sources than do any of the eight-hour standards analyzed. Control techniques used to attain the eight-hour standard are probably adequate to guarantee attainment of the one-hour standard. Therefore, there would be no significant incremental cost due to compliance with the one-hour standard.

The cost and economic analyses presented here examine the current eight-hour standard of 9 ppm, one observed exceedance and three alternative standard formulations.

The one observed exceedance form is a "deterministic" one in that it relates to a specific value that is fixed by its place in a frequency distribution of air quality data. In the case of one observed exceedance, it is the second-highest value in the ranked order set of measured 8-hour averaged CO values for a year. In this report, this value will be known as the 2nd-high value.

The three alternative formulations all involve (1) a "statistical" specification for the allowed violation rate dimension of a NAAQS and (2) a daily maximum one-hour specification for the periodic aggregation dimension of a NAAQS.* In summary form, the four alternative CO NAAQS investigated in this analyses are:

1. 9ppm/2nd-high non-overlappng 8-hour average in a year. (Hereafter cited as the 9/2nd-high standard.)
2. 9 ppm/1 expected exceedance daily maximum 8-hour average in a year. (Hereafter cited as 9/1 standard.)
3. 12 ppm/1 expected excedance daily maximum 8-hour average in a year. (Hereafter cited as a 12/1 standard.)

4. 15 ppm/1 expected exceedance daily maximum 8-hour average in a year.
(Hereafter cited as a 15/1 standard.)

1.2 STUDY OBJECTIVES

The primary objectives of this study are to:

- Estimate the relative hypothetical costs of attaining alternative National Ambient Air Quality Standards for carbon monoxide.
- Study the economic impacts that the hypothetical have controls on consumers and on industrial production.
- Determine the major sensitivity of results to certain study variables.

Each of these objectives is discussed below.

1.2.1 Cost Estimates

The hypothetical cost estimates consist of the direct costs of control measures which require carbon monoxide control, including the Federal Motor Vehicle Control Program. In cases where control of more than one pollutant is achieved by a particular control measure, costs are apportioned among the various pollutants, as described in the Cost Methodology sections.

*There are at least six attributes, or dimensions, of a NAAQS (McCurdy, 1984). The dimensions, and the corresponding item for carbon monoxide, are:

<u>Dimension</u>	<u>Example</u>
1. Concentration Level	9 ppm
2. Averaging Time	8 hours
3. Periodic Aggregation	Maximum 8-hour average in a day
4. Frequency of Repeated Peaks	(Not used)
5. Allowed Violation Rate	One expected exceedance per year
6. Data Handling and Analysis Conventions	Defined by 40 CFR and EPA Guidance

The cost estimates reflect total annualized cost of attaining alternative CO standards. This includes annualized capital charges on equipment as well as annual operating and maintenance/repair costs. Also included in the annualized cost estimates are potential savings due to decreased energy requirements resulting from certain control strategies.

It should be noted that no consideration is given here to SIP development costs, or to other costs incurred by States or local governments in implementing a CO NAAQS.

1.2.2 Economic Impacts

The second primary objective of this study is to assess economic impacts associated with the costs incurred by implementing the required set of control strategies. These economic impacts are divided into three areas, depending on where the direct effect is felt. The particular cost components differ among the set of control techniques hypothetically needed, but include estimates of costs imposed on industry and individuals.

Impacts on individual consumers arise primarily from mobile source control costs and are examined in two ways: per capita impacts and macro-economic impacts on the distribution of income. Industrial financial impacts result from the costs of stationary source control and are examined both in terms of (1) capital requirements imposed on industry and the ability of companies to bear the capital expense, and (2) inflationary and competitive impacts of annualized control costs of total production costs and product prices.

1.2.3 Sensitivity Analysis

The final objective of the study is to determine how sensitive the results are to certain assumptions. Exogenous variables such as growth rates and control effectiveness are examined using different assumptions to determine sensitivity of the resulting costs. Certain of the sensitivity analysis scenarios are deemed to be significant and therefore are subject to a complete analysis.

1.3 ORGANIZATION OF THE REPORT

Section 2 presents the study methodology. While it provides an overview of the study, it does not present complete methodologies for each analytical component; rather, it indicates what the components of the study are and shows how the various analytical pieces interact to produce estimated costs of attainment. Section 2 also presents the total annual costs of attaining the current as well as alternative eight-hour standards. These costs summarize all of the component costs calculated in later sections.

Section 3 presents the methodology for and results of the cost estimation for mobile source control measures. Included is a discussion of the procedures used to determine the amount of emissions reduction needed, the control strategy selected to attain the standard, and the degree of reduction and associated cost produced by the control measures. Estimates are made of the number of standard metropolitan statistical areas (SMSAs) that will comply with each standard using the control strategies under consideration. Results for various sensitivity analysis scenarios also are presented. Appendix A provides the detailed analysis of Federal Motor Vehicle Control Program costs for CO.

Section 4 presents results of the stationary source cost analysis by industry. The methodology and assumptions used to calculate these costs are presented in Appendix B.

Section 5 contains an analysis of the economic impacts of mobile source control requirements. While these impacts are not directly associated with a NAAQS, they are presented in order to provide a synoptic picture of mobile source impacts for environmental protection.

Section 6 analyzes stationary source economic impacts. The results indicate those industries for which control costs may present potential problems. Control costs for any stationary source category constitute less than 1% of total CO control costs.

REFERENCES FOR SECTION 1

1. McCurdy, Thomas. March 1984. "Miscellaneous Analyses of Alternative O₃ NAAQS Formulations and Their Impact on O₃ Non-Attainment and Cost Analysis Procedures." Ambient Standards Branch, U.S. EPA.
2. U.S. Environmental Protection Agency. 1985. Regulatory Impact Analysis for Carbon Monoxide (Revised). Ambient Standards Branch, Office of Air Quality Planning and Standards.

2. STUDY METHODOLOGY AND TOTAL COST

This section presents the total annualized cost of attaining alternative National Ambient Air Quality Standard (NAAQS) and various alternative standards for carbon monoxide. Figure 2-1 depicts the general procedure followed to determine the total cost of control. The program through which attainment is achieved consists of three areas of emission control: the Federal Motor Vehicle Control Program (FMVCP), in-use mobile source control, and stationary source control.

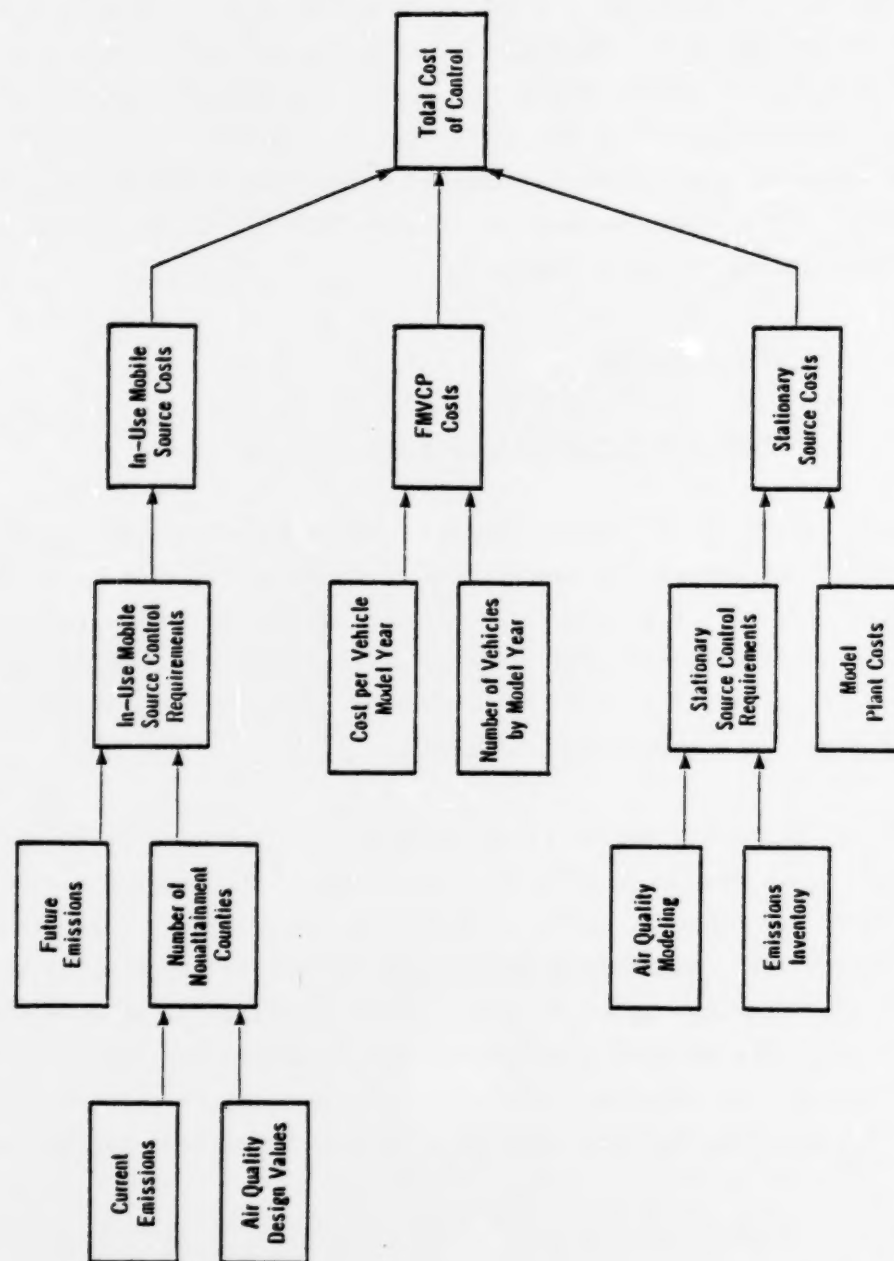
2.1 CONTROL PROGRAMS

2.1.1. Federal Motor Vehicle Control Program

The Federal Motor Vehicle Control Program provides substantial emission reductions across the country and their resulting costs comprise a basic component of the program to attain the NAAQS for carbon monoxide. While FMVCP control requirements are not directly related to the NAAQS program, they provide a baseline emission reductions guideline upon which the current and alternative standards can be based.

FMVCP includes a series of increasingly stringent tailpipe emission standards with which new motor vehicles must comply. The program includes control of light-duty vehicles (LDVs), light-duty trucks, heavy duty trucks, and motorcycles. Emission standards established by the program become increasingly stringent for later model years; thus, as more early model vehicles are retired, total fleetwide emissions are reduced. All of the analyses undertaken in this report assume that the current 3.4 grams per mile FMVCP standard for LDVs will be in effect throughout the period of analysis.

FIGURE 2-1
STUDY METHODOLOGY
FOR COST OF ATTAINING CO STANDARD



Since emission standards require different control technologies, their costs are calculated separately for each model year. A complete discussion of the methodology and results of the costs incurred due to FMVCP appears in Appendix A.

2.1.2 In-Use Mobile Source Control

Control programs used to achieve additional reductions in mobile source emissions necessary to attain NAAQS are aimed at reducing emissions from in-use vehicles. For purposes of this analysis, such measures include Inspection and Maintenance (I/M) programs for light-duty vehicles and Transportation Control Measures (TCMs) which reduce emissions by reducing travel and improving traffic flow. In designated nonattainment counties (those needing emission reductions), the amount of reduction is determined by current emissions, projected future emissions, and air quality levels that are present. The estimated emission reductions are expanded to the Standard Metropolitan Statistical Area (SMSA) level of analysis, which is the areal basis used in this report.

While the actual cost of these measures will vary considerably among local areas, this analysis uses average costs based on studies of programs already implemented in local areas. The magnitude of the cost in individual SMSAs is dependent upon the estimated vehicle population and the degree of emission reduction required. The particulars of the cost algorithm are presented in Section 3.

Because of the different nature of mobile source and stationary source emission problems and the location of the existing monitoring network, it is believed that recorded violations in nonattainment areas are a result of mobile sources and localized area sources. As part of this study, an analysis of the stationary source problem was conducted which indicates that stationary source emissions had negligible effects on monitor readings in most counties. Therefore, all of the needed reductions in each nonattainment county are provided by control of mobile source emissions.

2.1.3 Stationary Source Control

Stationary source control requirements were determined by examining the maximum air quality impact from individual sources in isolation. Source-specific data for emission and stack parameters were used to determine the maximum air quality impact of the plant's emissions.

Model plants were used to estimate the unit cost of alternative control techniques for each source category. The total cost of controlling point source emissions was calculated by applying the average unit cost data to actual levels of operation at each source. The costs were aggregated to obtain a national total. A more complete discussion of the calculation methodology is presented in Appendix B; the results are discussed in Section 4.

2.2 TOTAL COST

As discussed in Section 1.1, while the NAAQS for CO is expressed as both a one-hour and eight-hour standard, only the eight-hour standard alternatives are examined here, since, in all cases analyzed, compliance with the eight-hour standard assures compliance with the one-hour standard. Control requirements estimated by this study for the current eight-hour standard of 9 ppm 2nd-high eight-hour average and three alternative NAAQS formulations provide emission reductions necessary to meet almost all one-hour standards as well. Total control expenditures for any of these eight-hour standards exceed estimated expenditures for any feasible one-hour CO NAAQS.

Table 2-1 presents national variable costs of complying with alternative NAAQS's, ignoring net FMVCP costs. Variable costs are those that vary with the NAAQS being investigated. It should be noted that these costs do not include estimation of any cost of administering the standard. All costs represent net annualized costs incurred in the years indicated, measured in 1984 dollars. Any benefits arising from reduced fuel consumption for mobile and stationary sources are included. The costs estimated for compliance with each standard depend on assumptions made for each scenario. These assumptions include emission source growth rate, I/M and TCM control program effectiveness, and the initial air quality levels, as well as policy decisions

TABLE 2-1. ANNUALIZED VARIABLE CONTROL COSTS FOR ALTERNATIVE
8-HOUR CO NAAQS ASSUMING FUEL SAVINGS CREDIT^a

(in constant 1984 dollars x 10⁶)

Item	Alternative NAAQS(in ppm)			
	All Hours	Daily Maximum		
	9/2nd-High	9/1 ExEx	12/1 ExEx	15/1 ExEx
1987				
I/M ^b	232.7	184.3	51.1	34.5
TCM ^c	75.0	37.5	6.0	-2.5
Stationary Sources ^d	27.3	27.3	30.5	16.0
Total Incremental Costs	335.0	249.1	87.6	48.0
1990				
I/M	247.6	199.0	48.7	33.0
TCM	60.3	30.1	5.1	-2.1
Stationary Sources ^d	27.3	27.3	30.5	16.0
Total Incremental Costs	335.2	256.4	84.3	46.9
1995				
I/M	232.3	197.6	47.2	31.8
TCM	53.1	27.1	4.3	-1.8
Stationary Sources ^d	27.3	27.3	30.5	16.0
Total Incremental Costs	312.7	252.0	82.0	46.0

Note: ^aExcludes Federal Motor Vehicle Control Program costs, which do not vary by NAAQS analyzed. Annualized FMVCP costs are shown in Appendix A, Table A-11. The cost estimates are for the "primary case".

^bI/M = Inspection and Maintenance Programs.

^cTCM = Transportation Control Measure.

^dAnnualized stationary source control costs are non-linearly related to stringency of NAAQS because of fuel savings associated with CO controls in certain industry types.

regarding the level and form of the standard. A complete discussion of these assumptions appears in Section 3.

Stationary source controls do not vary with the number of allowed expected exceedances for any particular standard level. The modeling methodology used to estimate stationary costs is not sensitive to the allowed exceedances variable, so the number of sources not attaining a standard -- and hence their control costs -- do not change with number of allowed exceedances. The relatively small magnitude of stationary source controls vis-a-vis total costs minimizes the impact that this methodological problem has on the cost assessment results for most of the standards analyzed. This issue is discussed in more detail in Section 4 and Appendix B.

The national cost estimates are only one part of the picture with respect to impacts on the nation of alternative 8-hour CO NAAQS. Associated with each alternative is an estimate of the number of SMSAs that hypothetically cannot attain the CO NAAQS using reasonably available control measures (RACM). RACM control techniques are those that are currently operational and proven to be effective. For CO, these are inspection and maintenance programs and transportation control measures for mobile sources; and boilers, flares, incinerators, and operating changes for stationary sources. All of these techniques are discussed in more depth below.

If an area cannot achieve an alternative NAAQS using RACM technologies, no attempt is made in this analysis to "force" attainment by using more stringent, but unproved control technology. Thus, if the hypothetical control program devised for each SMSA needing control cannot achieve the standard, that fact is simply noted. The number of SMSAs projected to exceed the various CO NAAQS after implementing a RACM program is shown in Table 2-2. The same set of assumptions that were used to develop the data in Table 2-1 is used to develop Table 2-2.

TABLE 2-2. THE NUMBER OF SMSAs AND INDEPENDENT COUNTIES PROJECTED TO EXCEED ALTERNATIVE 8-HOUR CO NAAQS AFTER IMPLEMENTATION OF REASONABLY AVAILABLE CONTROL MEASURES^a

Year	Alternative NAAQS(in ppm)			
	All Hours	Daily Maximum		
	9/2nd-High	9/1 ExEx	12/1 ExEx	15/1 ExEx
1987	28	14	2	0
1990	10	6	0	0
1995	3	2	0	0

^aThese estimates are for the "primary case."

3. MOBILE SOURCE COST

Mobile sources account for over 70 percent of the mass of carbon monoxide emitted in the United States (EPA, 1984). Since the CO problem in most urban areas is caused by mobile sources, the majority of CO control costs will be borne by the mobile source sector.

This section provides information about 1) the process by which the cost estimates for mobile source controls were made, including the method by which needed reductions are calculated, 2) control strategies, and 3) costs of control. In addition, the critical assumptions made are presented along with their sensitivity analyses.

Complete details of the procedure for determining mobile control requirements and resulting costs can be found in a report produced by Stanford Research Institute, entitled "Methodologies to Conduct Regulatory Impact Analysis of Ambient Air Quality Standard for Carbon Monoxide" (SRI, 1979). Most of the inputs to this procedure have been updated to 1984, as noted in this Section.

3.1 COST ESTIMATION PROCESS

The process by which cost estimates were made includes determining baseline emissions, air quality design values, and needed reductions.

3.1.1 Baseline Emissions

Baseline emissions data were developed to provide information on the magnitude of CO emissions in each of 280 counties. These counties are considered either to be in nonattainment under the current standard or to be potentially in nonattainment under one or more of the alternative standards. The base year

emission inventory comes from EPA's existing emission data base. Projections of emissions for three critical future years are made taking into account growth as well as the mandated tailpipe emission standards for motor vehicles.

Emissions projections are made for the years 1984, 1987, 1990 and 1995. The baseline emissions data include contributions from both mobile and area sources, with mobile source emissions as the primary contributors. The current mobile source data are obtained from the EPA National Emission Data System (NEDS) file, and were assumed to represent 1982 emissions; growth and adjustment factors therefore were used to transform 1982 emissions to the 1984 baseline (Platte, 1985).

Projection of future mobile source emissions in 1984, 1987, 1990, and 1995 were calculated using MOBILE3, EPA's mobile source emission model, which incorporates the latest emission factors (EPA, 1984b). The emission projections take into account estimates of growth in vehicle miles traveled (VMT), as well as reductions in tailpipe emissions expected from the Federal Motor Vehicle Control Program, as projected by MOBILE3. The projections are based on the currently mandated 3.4 grams per mile (gpm) light duty vehicle standard. Since MOBILE3 provides no emission factors for California technology vehicles, separate California mobile source emission projections were made using data from the California Air Resources Board's equivalent of MOBILE3, EMFAC6 (CARB, 1985).

The original CO cost model (SRI, 1979) was designed to correct NEDS CO emissions from an assumed uniform 75°F temperature to each county's average January temperature, using ratios of mobile emission factors for the respective temperatures. Emission estimates in the current NEDS file are based on county-specific annual average temperatures. As described later in this Section, the current analysis has been performed with and without the original temperature correction factors to assess the sensitivity of the methodology to this variable.

Area source emissions also contribute to the baseline emissions inventory. Area sources include residential heating and some processes too small to be individually identified, including woodstoves (to the extent they are included in NEDS). Current area source emissions (for 1982) were also obtained from the NEDS data file. Future area source emissions were calculated using current emissions and an annualized growth rate that can be input to the program.

There has been some concern recently that high CO emissions from woodstoves would cause by themselves violations of the current CO standard in urban areas with a high usage of woodstoves. To date, OAQPS has no data to confirm or not confirm this statement. Even if woodstoves are a problem in some areas, they would not contribute much to the monitors that are used in this analysis (see the next Section). These monitors are traffic-oriented for the most part, and are not located in residential areas that generally are the source of most woodstove emissions. In addition, more than one-half of the areas investigated have relatively warm winters or are major metropolitan areas, neither of which is conducive to the use of woodstoves for primary wintertime heating. Thus, an under-representation of woodstove emissions from the NEDS inventory would not have much impact on results contained in this report. Perhaps a few areas would need more controls if woodstove emissions were included, but it is impossible to quantitatively address the issue because of lack of data.

Total baseline emissions are equal to the sum of mobile source and area source emissions. This calculation is performed for all counties in the analysis.

3.1.2 Air Quality Design Values

The design value for an area represents the estimated ambient CO concentration from which emission reductions are calculated in the strategy planning process. Design values which are used in this analysis were obtained from a review of 1981-1983 ambient air quality data in EPA's SAROAD data base, which comes from an extensive monitoring network. The data base represents the only

readily available source of consistent data for all of the areas investigated. Sufficient data are contained in the data base to estimate the approximate values based on alternative forms of the standard.

The design values included in this analysis are approximate and suitable only for analytical purposes in this assessment. In SIP revisions submitted to EPA, States calculate the actual design values used for attainment determinations and for planning purposes. The values are calculated for the appropriate form of the standard based on guidance provided by EPA (see CFR Part 51.)

The current CO standards specify that the eight-hour average of 9 ppm must not be exceeded more than once per year. In addition to assessing alternative standard levels in this analysis, alternative procedures for calculating exceedances of the standard also are considered. These procedures affect the form of the standard. Not only does the form influence determination of the number of exceedances of the standard, but it also impacts the calculation of an area's design values.

In its current form, the standard is based on the second-highest monitored value during a year in an area. However, this deterministic (observed once-per-year) approach has limitations in that it does not account for the stochastic nature of maximum CO concentrations. To maintain such a standard year after year necessitates a zero probability that the second-high value will ever exceed the standard. On a practical basis, permitting only a single absolute exceedance in a year means that there is some finite possibility of occasionally having two or more exceedances in a particular year.

To remedy this conflict and to adjust for the effect of missing data, EPA is considering defining the standard on a statistical basis whereby the expected number of exceedances per calendar year is determined. Statistical forms of the standard vary depending on whether all possible values or just daily maximum values are used, and how running averages are handled for the eight-hour standard.

For purposes of the analyses as summarized in this document, two interpretations of the statistical standard are used. For the one-hour standard, the hourly interpretation bases the design value on the ambient hourly concentration that on average will be exceeded once per year in each area. The daily interpretation, on the other hand, bases the standard on the number of days with maximum hourly CO averages above the level of the standard. This means that a day with two or more hourly values over the standard level counts as one exceedance of the standard level rather than two or more.

Statistical forms of the eight-hour standard follow the same basic approach, but the interpretation is complicated by running averages, as discussed by EPA in "Guidelines for the Interpretation of Air Quality Data with Respect to the National Ambient Air Quality Standards" (EPA, 1977). The current CO standard is chosen so that the second exceedance will not come from an eight-hour period which contained at least one hour in common with the first exceedance.

In calculating design values, the daily interpretation uses overlapping eight-hour averages in computing the expected number of exceedances. For each day, the highest of the 24 possible eight-hour averages is the daily maximum eight-hour average. With this method, the possibility arises that two daily exceedances could have common values. The other statistical approach (the running eight-hour average interpretation) uses all possible eight-hour averages for the year so that more than one exceedance per day could be counted. This is more stringent than the current form of the standard in that exceedances could be overlapping.

In the analysis of the three years of data from 1981 to 1983, design values based on the eight-hour statistical form of the standard are expected to fall between the third and fourth highest maximum value (whether hourly or daily). In selecting design values, the fourth highest value over the three year period was used. If only two years of data were available, the third highest value was chosen.

While design values are available for all major urban areas which comprise 60 to 70 percent of the nation's population, many non-urbanized areas of the country do not have valid air quality monitoring data from which to judge whether the area has a CO problem. For these areas, emission densities in the county were obtained in order to gain an indication of the potential problem in the county. These values then were compared to equivalent emission densities which serve as compatible surrogates for the various standard levels. A basic air pollution model was used to calculate equivalent emission densities that would lead to a concentration equal to the levels of the standard under a certain set of conservative conditions (SRI, 1979). Thus, for those counties not having design value data, emission densities are used as design value surrogates.

3.1.3 Assumptions Made in Calculating Needed Reductions in Mobile Source Emissions

One of the most controversial areas of air pollution analysis is the relationship between emissions and monitored air quality values. Changes in relative location of emission sources and air quality monitors can radically alter air quality readings. Therefore, all emissions within a county do not contribute equally to air quality readings.

The amount of emission reduction required in each county to meet each of the standards under consideration is calculated through the use of a modified rollback procedure (SRI, 1979) which assumes a linear relationship between emissions and air quality. In other words, a 10 percent improvement in the air quality design value is calculated to require a 10 percent reduction in emissions.

3.1.4 Calculation Procedure

The percent rollback was calculated for each county with a design value in the following manner:

$$\text{Percent rollback} = 100 \times \frac{(\text{Design value}) - (\text{Standard})}{\text{Design value} - \text{Background}}$$

This provides a percentage indicating the amount of improvement in air quality necessary to meet the standard. For counties where design values do not exist, the rollback is calculated by the following equation based on emission density data:

$$\text{Percent Rollback} = 100 \times \frac{(\text{Total emission density, tons/mi}^2/\text{yr}) - (\text{Standard Density})}{\text{Total emission density}}$$

where the standard density is an estimate, calculated by EPA, of emissions per square mile that result in air quality readings equal to the standards.

Both of these calculation procedures provide an estimate of the percent improvement in air quality required to meet the standard. Once this is accomplished, the allowable emissions are calculated for each county under each standard for each analysis year. Allowable emissions are defined as the maximum level of effective emissions within a county that produces air quality readings that comply with a particular standard, as calculated by the rollback procedure:

$$\text{Allowable emissions} = (1 - \frac{\% \text{ rollback}}{100\%}) \times (\text{Current effective emissions})$$

The concept of effective emissions is used to reflect the relative impact of various source categories. Effective emissions are obtained by considering the current or future baseline emissions and weighting the components by factors chosen to estimate the relative contributions of different sources to air quality readings. Based on results of modeling studies, the assumption is made that only a portion of the total area source emissions contributes to an area's maximum CO values, which comes from sites that reflect more localized sources. For purposes of this study, the effective emissions which are assumed to impact monitored values are equal to 100 percent of mobile source emissions and 20 percent of area source emissions (SRI, 1979). These contributions may be varied in the algorithms used. See Section 3.4.

Since point source emissions do not affect air quality readings and no area source control measures are considered, any reduction required to meet the allowable emissions levels must be supplied through control of mobile source emissions. Thus, the needed mobile source reduction equation is:

$$\text{Needed mobile source reduction} = \text{Total effective emissions in any year} - (\text{Allowable effective emissions})$$

Needed reductions were calculated for 1987, 1990, and 1995, for the current and relaxed standards, and for 1990 and 1995 for more stringent alternative standards.

Point source emissions (i.e., those from major industrial processes) are not considered to contribute to monitored CO values. The stationary sources analysis (presented in Section 4 and Appendix B) indicates that point source emissions have negligible effects on monitored readings in most counties.

Since it is the design value and not emissions which determines whether or not a county requires additional control, no counties are exempted from the need for additional control by the assumption of the reduced effect of area source emissions. These assumptions cause mobile source emissions to be weighted more heavily in attainment strategies, to simulate observed contributions. A further discussion of this is presented as part of the discussion on emissions growth sensitivity in Section 3.4.

3.2 CONTROL STRATEGIES: COST DEVELOPMENT AND EMISSION REDUCTION

Mobile source control strategies considered in this study are divided into two types: Inspection and Maintenance (I/M), and Transportation Control Measures (TCM). TCM programs include both area-wide measures, which are designed to reduce total travel in an area, and localized measures, which respond to "hot spot" problems by improving traffic flow.

While the cost and effectiveness of both I/M and TCM programs vary depending upon the characteristics of the individual areas and programs, this study uses

average cost and reduction estimates for the programs to calculate total cost. These average costs are based on studies of programs that have been implemented in selected local areas across the country.

3.2.1 Inspection/Maintenance Program

3.2.1.1 Description of Programs Used

Fleet-wide emission reductions achieved by I/M programs will be dependent on a number of factors, one of which is the percentage of vehicles that fail the test and thus have to undergo repairs. Other influencing factors include ambient temperature, location, year of implementation, and extent of mechanic training achieved by an I/M program.

Table 3-1 presents example estimated emissions reductions for 50°F for I/M programs using 20 and 30 percent failure rates for pre-1981 vehicles, with 3.0 and 1.2 percent CO cutpoints for 1981 and later vehicles. The table also indicates that the amount of reduction obtained is dependent upon the number of years the program has been in operation, while the year in which the program starts is dependent upon a status schedule generated by EPA (EPA, 1985). Presently, many areas in the United States are required to establish I/M programs for the control of CO/HC emissions in order to meet current ambient air quality standards for CO and/or ozone. It is assumed that any area with this designation has initiated its I/M program in 1984. Programs have been operating in some areas for a number of years. Assuming 1984 commencement for all existing and required programs will result in some underestimation of I/M effectiveness for programs in place earlier, especially for the 1987 analysis year. Since only six programs began before 1982, the overall effect of this assumption will be small. Since MOBILE3 does not provide I/M program effectiveness for California, these factors were estimated by adjusting MOBILE2 California effectiveness factors for changes in non-I/M emission factors between MOBILE2 and MOBILE3.

TABLE 3-1

PERCENTAGE REDUCTION IN
MOBILE SOURCE EMISSIONS FROM I/M PROGRAMS FOR LDVs^a

Location -----	Initiation Year -----	Percent Failure Rate -----	Target Year		
			1987 -----	1990 -----	1995 -----
Low Altitude	1984	20	24.4	27.6	28.5
		30	28.6	31.3	32.1
	1986	20	12.3	24.8	27.7
		30	15.6	29.2	31.3
	1987	20		23.3	26.9
		30		27.3	30.5
High Altitude	1984	20	24.0	26.9	27.8
		30	28.5	31.0	31.1
	1986	20	12.5	24.9	26.9
		30	16.1	29.6	30.5
	1987	20		23.2	26.4
		30		27.8	30.2
California	1984	20	23.6	26.2	27.1
		30	27.0	29.5	30.7
	1986	20	12.4	23.7	26.4
		30	15.2	27.6	29.9
	1987	20		22.5	25.6
		30		25.8	29.1

a - Reductions achieved in total mobile source emissions resulting from I/M programs for light duty vehicles. Other vehicle classes are not required to be inspected.

These percentages apply to a 50 degree Fahrenheit average temperature.

Some counties are identified as needing emission reduction for attainment of one of the more stringent alternative CO standards, without currently needing an I/M program. If such a county is located in a State which has a current or planned I/M program, it is assumed that the county will implement I/M in 1986. In other States, a county needing reductions is assumed to begin the program in 1987. This is to account for the lead time needed to obtain legislative authority at the State level.

In urban areas, auto emissions affect the air quality of the entire area, not just the county in which the specific problem occurs. Emission reductions can be guaranteed only if every county in the urban area implements an I/M program similar to that required in the problem county. It therefore is assumed that Bureau of Census Standard Metropolitan Statistical Areas (SMSAs) which require control in at least one of their counties implement an I/M program at the tightest stringency level required, and then implement the same program in all of their other counties as well.

3.2.1.2 I/M Costs

The annual expenditure required for an I/M program is divided into inspection cost, repair cost, and fuel savings (a negative cost). Total costs for each area implementing I/M are calculated by estimating the vehicle population in each analysis year and multiplying the number of cars affected by the unit costs.

The inspection cost, levied on each car, is designed to include costs of operating and maintaining the program and an annual capital charge to pay for the inspection facility. While these costs can vary from \$2.50 to \$10.00 depending on the particular program (EPA, 1985), the average cost is assumed to be \$7.00 for each car inspected. Cars which fail the inspection will be required to undergo repairs in order to correct the problem. Preliminary data provided by EPA's Office of Mobile Sources (OMS) indicates that the average cost of repairs is a function of (1) the proportion of pre-1981 to post-1981 cars in the fleet inspected, (2) stringency level, and (3) year of analysis. The average repair cost data takes the form of a matrix (Lorang, 1985):

	Stringency		
	<u>20%</u>	<u>30%</u>	<u>40%</u>
1987	\$ 20.88	\$ 21.67	\$ 22.28
1990	17.58	18.79	19.79
1995	14.82	16.60	18.20

There is uncertainty regarding the true repair cost estimate and per-car costs certainly will vary around these mean estimates.

Improved operation of repaired vehicles is expected to result in some small fuel savings for post-1981 cars. The fuel savings vary by (1) the proportion of post-1981 cars in the fleet inspected, (2) I/M stringency level, and (3) year of analysis. The average fuel savings estimate takes the form of a matrix (Lorang, 1985):

	Stringency		
	<u>20%</u>	<u>30%</u>	<u>40%</u>
1987	0.4%	0.4%	0.5%
1990	0.6	0.7	0.8
1995	0.9	1.1	1.2

Total fuel savings are calculated based on assumed values of 550, 490, and 420 gallons per year per car for 1987, 1990 and 1995, respectively, and \$1.20 per gallon of gasoline (EEA, 1984; EIA, 1984).

Unit costs presented here do not include allowances for the cost of peoples' time to have their cars inspected and repaired. While people admittedly will suffer some inconvenience from I/M programs, the costs of such losses in time are not large since the actual inspection lasts only a few minutes. In one study of an operational I/M program specifically concerned with developing detailed cost information on all aspects of the program, the average value of time spent waiting for the inspection and needed repairs, was \$1.68 per car inspected (Palmini and Rossi, 1980). Since two pollutants are involved in this I/M program, CO and HC, the time costs attributable to CO would be \$0.84 per car.

3.2.1.3 Allocation of I/M Costs for CO Control

Costs mentioned in the previous Section represent the total cost of implementing I/M in any county. Counties specified by EPA as implementing I/M by 1985 were assumed to do so because of the need for both CO and HC emission control. For these programs, total I/M costs should not be attributed totally to CO control, rather they should be equally divided between the two pollutants. Therefore, annual I/M costs are divided by two for all counties instituting I/M by 1985, and for all counties currently exceeding the ozone NAAQS by 0.03 ppm (i.e., an ozone design value ≥ 0.15 ppm). For other areas which are identified in this analysis as needing I/M for CO control, all of the costs are attributed to CO.

3.2.2 Transportation Control Measures

3.2.2.1 Program Description

Transportation Control Measures reduce emissions by reducing total vehicle miles traveled (VMT), by reducing average daily travel (ADT) for specific roadways, or by improving traffic flow. Control measures include transit system improvements, ridesharing programs, road user charges and congestion pricing, traffic signal system improvement, and exclusive bus or car pool lanes. These methods are categorized as either local or area TCM measures.

Local TCM include signal timing, computerized control of street flow, freeway surveillance and control, and truck restrictions on certain streets. These measures are intended to improve traffic flow and alleviate CO "hot spot" problems. Areawide TCM, which include ridesharing, express buses, local bus improvements, and work rescheduling are intended to reduce total emissions in an area by reducing VMT and the number of trips.

TCM options are used where the needed reduction is 5 percent or less, (assuming no other county in the urbanized area requires I/M), and in addition to I/M in counties where I/M is not sufficient to provide the projected needed reductions in mobile source emissions.

3.2.2.2 TCM Cost

Emission reductions and costs per unit of reduction of TCM controls can vary significantly depending on local conditions. However, EPA has undertaken an assessment of TCM in order to determine generalized emission reductions and costs for use in this analysis (SRI, 1979). As a result, an estimate of up to a 3 percent reduction in mobile source emissions is assumed to be obtained through local TCM. Although the measures will be somewhat different depending on the locality, the cost of such measures is estimated at \$230/ton of CO reduction (SRI, 1979).

Area-wide TCM may reduce emissions by an additional 2 percent. The marginal cost of these reductions, however, is not constant. The first one percent reduction in emissions from area TCM is estimated to cost \$550/ton of CO reduced, with the last one percent costing \$12,600/ton reduced (SRI, 1979). The last one percent includes such costly measures as transit improvements.

A byproduct of reducing VMT is a reduction in fuel consumption. By reducing total travel, a factor of 1088 gallons/ton of CO reduced is used to estimate these fuel savings (SRI, 1979). This value then is subtracted from the annual cost to estimate the net annual cost of the program.

As in the case of I/M, only a portion of these costs are attributable to CO control in many areas. Since some TCM also can be used to reduce HC, emissions, reduce traffic congestion and travel time, and save energy, this analysis allocates a maximum of 50 percent of the cost and savings to CO control in areas with both a CO and ozone problem. For CO-only non-attainment areas, 100% of the costs and savings attributable to TCM is allocated to CO..

3.2.3 Total Cost of Mobile Source Control

The total annual net cost of mobile source control is the sum of three CO-only components for each area: 1) the cost of FMVCP, 2) the I/M cost, and 3) the TCM cost. These are discussed in detail in subsequent sections.

3.3 COST OF ATTAINING CURRENT AND ALTERNATIVE 8-HOUR CO NAAQS

3.3.1 Assumptions

Total nationwide CO NAAQS costs reflect variable expenditures required to attain an alternative NAAQS for CO plus the costs of complementary mobile source emission programs (e.g., FMVCP) which do not change under alternative NAAQS's. The variable expenditures are associated with 3 major control programs:

- Inspection and Maintenance (I/M)
- Transportation Control Measures (TCM)
- Stationary Source Emission Controls

The stationary source control estimates are derived via a methodology that is independent of mobile and area sources impacts. The only factors that influence stationary source control sources are the source-specific emission rates and modeling methodology. (See Appendix B.) Because stationary source control costs are relatively small, sensitivity analyses were not undertaken on the various inputs that went into the predictive equations. Thus, we have only a "best estimate" for stationary source control costs.

A number of sensitivity analyses were undertaken on mobile source oriented control costs inputs, however. These costs include implementing I/M and TCM programs and FMVCP controls. FMVCP controls do not vary by NAAQS level, so they are the same for all alternative ambient standards investigated here. A FMVCP of 3.4 grams per mile instituted for 1981 model year cars and beyond is assumed. Variable costs associated with alternative NAAQS are those related to I/M and TCM. We focus on these two programs in this Section.

There are a number of variables that affect total I/M and TCM costs in the country. They are listed below, along with the primary, or usual, assumption that the variables take. The usual assumptions are considered to be conditions associated with reasonably available control measures, or RACM. These variables are:

- NAAQS Standard definition: Four alternatives were investigated, as noted in Section 1.1.
- Growth in emissions: Mobile source emissions grow approximately at a one percent per annum compound rate. The growth rate used depends upon the time interval; for the 1982-1987 time period the growth rate is 1.2% per year, for 1987-1990 it is 1.1% per year, and for 1990-1995 it is 1.05% per year. Area source emissions grow at a rate of 2.5% per year.
- Source interaction: Stationary source emissions do not affect the analysis; only 20% of area source emissions affect the analysis.
- CO background concentration: 0 ppm. A one ppm background level is also considered.
- I/M stringency (or rejection rate): 20% of all LDVS, or 30% if needed. A 40% stringency level is considered to be an alternative. Once I/M goes into an area, it stays in for the entire period of analysis.
- I/M effectiveness in cold-weather area: I/M effectiveness is assumed to vary by temperature. OMS research indicates that I/M effectiveness can be approximated by a straight-line relationship between the following end points: (1) 50% effective at 20°F, and (2) 100% effective at 70°F (Armstrong, 1985). The temperature of interest is the mean daily average temperature for the three month period of November-January.
- TCM effectiveness: TCM can reduce the critical county mobile source emissions by a maximum of 5%. (See Section 3.2.2.2.) Once a TCM program is implemented, it remains in during the period of analysis.
- Per unit cost figures:
 - I/M inspection fee: \$ 7.00 per LDV
 - I/M repair charge: cost per repaired LDV is in 3.2.1.2.
 - I/M capital charge: \$8.00 per LDV
 - price of gasoline: \$ 1.20 per gallon

In the following subsections, the RACM costs of attaining--or coming as close as possible to attaining--the various CO NAAQS are presented and discussed. In addition, the impact on cost of changing one or several of the above assumptions will be examined and compared to the primary case as a test of sensitivity of the cost analysis to analytical assumptions.

3.3.2 Federal Motor Vehicle Control Program (FMVCP)

The FMVCP controls tailpipe emissions of CO, hydrocarbons, and nitrogen oxides from cars, trucks, and motorcycles. Appendix A presents an analysis of the program's cost for these vehicle categories as well as a discussion of the rationale for allocating certain FMVCP costs to CO. Table A-11 summarizes total 1987, 1990, and 1995 FMVCP costs attributable to CO for a 3.4 gpm FMVCP. In general, the costs were divided equally among the pollutants controlled by each phase and/or component of the program (i.e., one, two, or all three).

Costs for light-duty vehicles assume that 1981 and later model year cars meet the 3.4 grams/mile emission standard as mandated by the Clean Air Act. While there are several alternative technologies which might be used to achieve the standard, most auto manufacturers plan to use a three-way catalytic converter in combination with an oxidation catalyst, the latter primarily for CO control. The costs presented in this analysis reflect the allocation of estimated costs for such a system among CO, HC, and NO_x.

In addition to the hardware costs, FMVCP annualized costs also include estimates of the costs of savings resulting from changes in operation and maintenance, changes in fuel economy, and fuel price differentials. The underlying rationale for these estimates is presented in Appendix A.

As mentioned, FMVCP costs are incurred regardless of the level or form of the standard. Thus, they remain a constant cost in all scenarios analyzed. Because FMVCP costs are a constant, they will not be presented in the sensitivity analysis output tables.

It should be mentioned that FMVCP costs would vary greatly if a waiver of the 3.4 gpm CO standard would be granted. (At one time, a 7.0 gpm FMVCP starting with 1981 model year cars, and remaining in effect for two years, was discussed.) Such a waiver is not seriously being contemplated, however, so its possibility was ignored in this analysis.

3.3.3 Annualized Mobile Source Cost of Attaining Current and Alternative NAAQS Levels

Annualized mobile source costs of attaining the various CO standards analyzed vary widely depending upon the assumptions made. The "primary case" assumptions, result in an estimated national net control cost for the current 9 ppm 2nd-high standard of about \$343 million in 1987, \$332 million in 1990, and \$313 million in 1995. However, not all areas can attain this standard by the years analyzed. The number of residual non-attaining areas is estimated to be 28 in 1987, 10 in 1990, and 2 in 1995 for the primary case.

Both the estimated annualized national control costs and residual non-attainment areas decrease for the alternative NAAQS investigated. This is shown in Tables 3-2 to 3-4 for the primary case and other scenarios.

3.4 SENSITIVITY ANALYSES

Several different sets of alternative analytical assumptions were formulated in order to determine how sensitive the cost and residual non-attainment estimates are to the assumptions made. These sets are known as Cases #2 through #7. (Case #1 is the primary case.) The cases are aggregated into two major case categories: data base assumptions, and I/M assumptions. The differences in each case are described below, and results are shown in Tables 3-2 through 3-13.

As mentioned previously, the assumptions used make a large difference in the cost and residual non-attainment estimates. For instance, annualized 1987 control cost estimates for the current 9 ppm 2nd-high standard vary from a low of \$227.5 million to a high of \$335.5 million. This range of \$108 million is almost 35% of the primary case estimate of \$307.7 million annualized costs. The estimated number of residual non-attainment areas in 1987 varies from 14 (for Case #4) to 45 (for Case #5). This is a very large difference. The primary case estimate is 28 residual non-attaining areas in 1987 for the 9/2nd-high standard.

TABLE 3-2

1987 MOBILE SOURCE VARIABLE CONTROL COSTS SENSITIVITY ANALYSIS:
DATA BASE ASSUMPTIONS

(In constant 1984 dollars x 10⁶)

Case No.	Case	Alternative NAAQS (in ppm)				
		All Hours	Daily Maximum Standards			
		9	2nd-High	9/1 ExEx	12/1 ExEx	15/1 ExEx
1.	Primary Case					
	Control Costs	307.7		221.8	57.1	32.0
	Residual Non-Attain. Areas	28		14	2	0
2.	1984 Base Year					
	Control Costs	335.5		256.8	79.1	46.0
	Residual Non-Attain Areas	45		26	4	1
3.	1988 Analysis Year					
	Control Costs	227.5		188.2	49.7	34.0
	Residual Non-Attain. Areas	21		10	1	0
4.	1 ppm CO Background					
	Control Costs	310.2		249.0	46.2	28.7
	Residual Non-Attain. Areas	31		16	2	0

TABLE 3-3
1990 MOBILE SOURCE VARIABLE CONTROL COSTS SENSITIVITY ANALYSIS:
DATA BASE ASSUMPTIONS

(In constant 1984 dollars x 10⁶)

Case No.	Case	Alternative NAAQS (in ppm)				
		All Hours		Daily Maximum Standards		
		9 2nd-High	9/1 ExEx	12/1 ExEx	15/1 ExEx	
1.	Primary Case Control Costs Residual Non-Attain. Areas	307.9 10	229.1 6	53.8 0	30.9 0	
2.	1984 Base Year Control Costs Residual Non-Attain Areas	363.1 24	279.6 13	76.6 1	43.8 0	
3.	1988 Analysis Year Control Costs Residual Non-Attain. Areas	239.7 10	201.5 6	47.0 0	32.1 0	
4.	1 ppm CO Background Control Costs Residual Non-Attain. Areas	321.6 17	256.9 7	44.1 0	28.1 0	

TABLE 3-4

1995 MOBILE SOURCE VARIABLE CONTROL COSTS SENSITIVITY ANALYSIS:
DATA BASE ASSUMPTIONS

(In constant 1984 dollars x 10⁶)

Case No.	Case	Alternative NAAQS (in ppm)				
		All Hours		Daily Maximum Standards		
		9	2nd-High	9/1 ExEx	12/1 ExEx	15/1 ExEx
1.	Primary Case					
	Control Costs	285.4		224.7	51.5	30.0
	Residual Non-Attain. Areas	3		2	0	0
2.	1984 Base Year					
	Control Costs	337.5		263.1	73.3	42.1
	Residual Non-Attain Areas	10		6	0	0
3.	1988 Analysis Year					
	Control Costs	224.6		189.9	45.6	31.0
	Residual Non-Attain. Areas	3		2	0	0
4.	1 ppm CO Background					
	Control Costs	297.3		239.2	42.6	27.6
	Residual Non-Attain. Areas	7		4	0	0

TABLE 3-5

RELATIVE (TO THE PRIMARY CASE) CHANGE IN MOBILE SOURCE VARIABLE
CONTROL COSTS FOR 1987: DATA BASE ASSUMPTIONS

Case No.	Case	Alternative NAAQS (in ppm)				
		All Hours	Daily Maximum Standards			
		9 2nd-High	9/1 ExEx	12/1 ExEx	15/1 ExEx	
1.	Primary Case					
	Control Costs (\$ x 10 ⁶)	307.7	221.8	57.1	32.0	
	Residual Non-Attain. Areas	28	14	2	0	
2.	1984 Base Year					
	Percent Change in Costs	+9.0	+15.7	+38.5	+43.7	
	Change in Residual Areas	+17	+12	+2	+1	
3.	1988 Analysis Year					
	Percent Change in Costs	-26.1	-15.2	-13.0	+6.2	
	Change in Residual Areas	-7	-4	-1	0	
4.	1 ppm CO Background					
	Percent Change in Costs	+0.8	+12.3	-19.1	-10.3	
	Change in Residual Areas	+3	+2	0	0	

TABLE 3-6
RELATIVE (TO THE PRIMARY CASE) CHANGE IN MOBILE SOURCE VARIABLE
CONTROL COSTS FOR 1990: DATA BASE ASSUMPTIONS

Case No.	Case	Alternative NAAQS (in ppm)				
		All Hours	Daily Maximum Standards			
		9	2nd-High	9/1 ExEx	12/1 ExEx	15/1 ExEx
1.	Primary Case					
	Control Costs (\$ x 10 ⁶)	307.9		229.1	53.8	30.9
	Residual Non-Attain. Areas	10		6	0	0
2.	1984 Base Year					
	Percent Change in Costs	+17.9		+22.0	+42.4	+41.7
	Change in Residual Areas	+14		+7	+1	0
3.	1988 Analysis Year					
	Percent Change in Costs	-22.2		-12.1	-12.6	+3.9
	Change in Residual Areas	0		0	0	0
4.	1 ppm CO Background					
	Percent Change in Costs	+4.4		+12.1	-18.0	-9.1
	Change in Residual Areas	+7		+1	0	0

TABLE 3-7
RELATIVE (TO THE PRIMARY CASE) CHANGE IN MOBILE SOURCE VARIABLE
CONTROL COSTS FOR 1995: DATA BASE ASSUMPTIONS

Case No.	Case	Alternative NAAQS (in ppm)			
		All Hours 9 2nd-High	Daily 9/1 ExEx	Maximum 12/1 ExEx	Standards 15/1 ExEx
1.	Primary Case Control Costs (\$ x 10 ⁶) Residual Non-Attain. Areas	285.4 3	224.7 2	51.5 0	30.0 0
2.	1984 Base Year Percent Change in Costs Change in Residual Areas	+18.3 +7	+17.1 +4	+42.3 0	+40.3 0
3.	1988 Analysis Year Percent Change in Costs Change in Residual Areas	-21.3 0	-15.5 0	-11.5 0	+3.3 0
4.	1 ppm CO Background Percent Change in Costs Change in Residual Areas	+4.2 +4	+6.5 +2	-17.3 0	-8.0 0

TABLE 3-8
1987 MOBILE SOURCE VARIABLE CONTROL COSTS SENSITIVITY ANALYSIS:
I/M ASSUMPTIONS

(In constant 1984 dollars x 10⁶)

Case No.	Case	Alternative NAAQS (in ppm)				
		All Hours	Daily Maximum Standards			
		9	2nd-High	9/1 ExEx	12/1 ExEx	15/1 ExEx
1.	Primary Case					
	Control Costs	307.7		221.8	57.1	32.0
	Residual Non-Attain. Areas	28		14	2	0
5.	40% Maximum Stringency					
	Control Costs	335.4		209.4	58.8	35.5
	Residual Non-Attain. Areas	25		13	1	0
6.	50% I/M Effectiveness					
	Control Costs	304.5		215.5	51.8	27.2
	Residual Non-Attain. Areas	29		15	2	0
7.	100% I/M Effectiveness					
	Control Costs	271.0		207.3	44.0	35.7
	Residual Non-Attain. Areas	13		7	0	0

TABLE 3-9
1990 MOBILE SOURCE VARIABLE CONTROL COSTS SENSITIVITY ANALYSIS:
I/M ASSUMPTIONS

(In constant 1984 dollars x 10⁶)

Case No.	Case	Alternative NAAQS (in ppm)				
		All Hours	Daily Maximum Standards			
		9 2nd-High	9/1 ExEx	12/1 ExEx	15/1 ExEx	
1.	Primary Case Control Costs Residual Non-Attain. Areas	307.9 10	229.1 6	53.8 0	30.9 0	
5.	40% Maximum Stringency Control Costs Residual Non-Attain. Areas	336.9 10	219.8 6	55.4 0	32.5 0	
6.	50% I/M Effectiveness Control Costs Residual Non-Attain. Areas	311.3 13	229.5 6	49.5 0	26.9 0	
7.	100% I/M Effectiveness Control Costs Residual Non-Attain. Areas	276.6 2	220.3 1	43.4 0	34.4 0	

TABLE 3-10
1995 MOBILE SOURCE VARIABLE CONTROL COSTS SENSITIVITY ANALYSIS:
I/M ASSUMPTIONS

(In constant 1984 dollars x 10⁶)

Case No.	Case	Alternative NAAQS (in ppm)				
		All Hours	Daily Maximum Standards			
		9	2nd-High	9/1 ExEx	12/1 ExEx	15/1 ExEx
1.	Primary Case Control Costs Residual Non-Attain. Areas	285.4 3		224.7 2	51.5 0	30.0 0
5.	40% Maximum Stringency Control Costs Residual Non-Attain. Areas	311.1 3		218.6 2	53.1 0	32.7 0
6.	50% I/M Effectiveness Control Costs Residual Non-Attain. Areas	287.6 5		225.4 1	47.8 0	26.6 0
7.	100% I/M Effectiveness Control Costs Residual Non-Attain. Areas	261.1 1		221.2 0	43.4 0	33.4 0

TABLE 3-11

RELATIVE (TO THE PRIMARY CASE) CHANGE IN MOBILE SOURCE
VARIABLE CONTROL COSTS FOR 1987: I/M ASSUMPTIONS

Case No.	Case	Alternative NAAQS (in ppm)				
		All Hours	Daily Maximum Standards			
		9	2nd-High	9/1 ExEx	12/1 ExEx	15/1 ExEx
1.	Primary Case					
	Control Costs (\$ x 10 ⁶)	307.7		221.8	57.1	32.0
	Residual Non-Attain. Areas	28		14	2	0
5.	40% Maximum Stringency					
	Percent Change in Costs	+9.0		-5.6	+3.0	+10.9
	Change in Residual Areas	-3		-1	-1	0
6.	50% I/M Effectiveness					
	Percent Change in Costs	-1.0		-2.8	-9.3	-15.0
	Change in Residual Areas	+1		+1	0	0
7.	100% I/M Effectiveness					
	Percent Change in Costs	-11.9		-6.5	-22.9	+11.6
	Change in Residual Areas	-15		-7	-2	0

TABLE 3-12

RELATIVE (TO THE PRIMARY CASE) CHANGE IN MOBILE SOURCE
VARIABLE CONTROL COSTS FOR 1990: I/M ASSUMPTIONS

Case No.	Case	Alternative NAAQS (in ppm)			
		All Hours	9/1 ExEx	12/1 ExEx	15/1 ExEx
1.	Primary Case Control Costs (\$ x 10 ⁶) Residual Non-Attain. Areas	307.9 10	229.1 6	53.8 0	30.9 0
5.	40% Maximum Stringency Percent Change in Costs Change in Residual Areas	+9.4 0	-4.1 0	+3.0 0	+5.2 0
6.	50% I/M Effectiveness Percent Change in Costs Change in Residual Areas	+1.1 +3	+0.2 0	-8.0 0	-12.9 0
7.	100% I/M Effectiveness Percent Change in Costs Change in Residual Areas	-10.2 -8	-3.8 -5	-19.3 0	+10.2 0

TABLE 3-13
RELATIVE (TO THE PRIMARY CASE) CHANGE IN MOBILE SOURCE
VARIABLE CONTROL COSTS FOR 1995: 1/M ASSUMPTIONS

Case No.	Case	Alternative NAAQS (in ppm)				
		All Hours	Daily Maximum Standards			
		9	2nd-High	9/1 ExEx	12/1 ExEx	15/1 ExEx
1.	Primary Case Control Costs (\$ x 10 ⁶) Residual Non-Attain. Areas	285.4 3		224.7 2	51.5 0	30.0 0
5.	40% Maximum Stringency Percent Change in Costs Change in Residual Areas	+9.0 0		-2.7 0	+3.1 0	+9.0 0
6.	50% 1/M Effectiveness Percent Change in Costs Change in Residual Areas	+0.8 +2		+0.3 -1	-7.2 0	-11.3 0
7.	100% 1/M Effectiveness Percent Change in Costs Change in Residual Areas	-8.5 -2		-1.6 -2	-15.7 0	+11.3 0

The sensitivity results are organized into two sets of 6 tables. Each set contains the primary case and 3 alternative cases. The first set involves cases focused on alternative assumptions regarding the data base, including its base year, analysis year, and CO background concentration. The second set poses alternative cases for I/M program assumptions. These include stringency level or rejection rate of the program, and effectiveness of the I/M program in cold-weather areas.

The first three tables within a set contain estimates of the absolute costs and numbers of residual nonattainment areas for the three years of analysis. The remaining three tables within a set contain relative change estimates for the alternative cases as compared to the primary case. There is one table for each year of analysis. The relative change indices are computed thusly:

$$\% \text{ change in control costs} = \frac{\text{Estimated costs for the alternative} - \text{Estimated cost for the primary case}}{\text{Estimated costs for the primary case}}$$

$$\text{Change in residual non-attainment area} = \frac{\text{Estimated residual areas for the primary case} - \text{Estimated residual areas for the alternative}}{\text{Estimated residual areas for the primary case}}$$

Thus, if an entry in any of the relative change tables is negative, it means that costs for the alternative are lower than the primary case or there are fewer residual non-attainment areas for the alternative than for the primary case.

As can be seen, these can be a positive change in costs associated with an alternative and a negative change in residual non-attainment areas -- or vice versa. There also can be no change in one or both of these items with either a positive or negative change in the other. In other words, there can be numerous possible combinations of directional changes in the costs and residual non-attainment areas indices. In addition, the directional changes can vary over time (i.e., 1987, 1990, or 1995) or by the standard level.

The reason for the fairly complex pattern of change in the relative change tables is the logic used for developing each area's control strategy and the fuel savings attached to the strategies. For example, if by changing a particular assumption an area goes from a situation requiring I/M at 20% to one where a TCM program using local strategies only is needed, control costs would drop dramatically, but the non-attainment situation would not change. In some areas, relaxing the standard from 12/1 to 15/1 actually causes control costs to increase because TCMs are no longer required. (At low levels of use, TCMs save money because of fuel savings.)

We turn to a brief description of the alternative cases investigated in this sensitivity analysis.

3.4.1 Case #2: 1984 Base Year

The primary case uses 1982 as the base year of analysis because it is the mid-point of the 1981-1983 time period used for air quality data. Some reviewers of drafts of this report object to this choice of base year as the 1981-1983 air quality data are used to define the design value in an area as of January 1, 1984. To them, 1984 should be the base year.

Having a different base year obviously affects the results. A 1982 base year, in essence, gives MOBILE3 two more years in which to reduce mobile source emissions due to FMVCP.

Compared to the primary case, with its 1982 base year, Case #2 results in about a 9 percent increase in costs for the 9 ppm, 2nd-high standard in 1987. The number of residual non-attainment areas increases greatly (+17) for the same standard and time period. This pattern holds time for almost all of the alternative NAAQS and time periods investigated.

3.4.2 Case #3: 1988 Analysis Year

The EPA MOBILE3 mobile source emission projection model was used to project composite fleet emissions and I/M effectiveness. Since MOBILE3 projects for

January 1 of each year, it could be argued that 1988 rather than 1987 would be the proper MOBILE3 projection year for assessment of compliance with December 31, 1987 Clean Air Act for attainment of the CO standard. As shown in Table 3-2 through 3-7, this change results in somewhat fewer nonattainment areas and lower costs in 1988 than in the base case of 1987. Costs in 1990 and 1995 are also generally lower, since the first analysis year is the controlling factor in designation of required control programs.

3.4.3 Case #4: 1 ppm CO Background

The primary case assumes a 0 ppm CO background level. This will not always be the case, so a case with 1 ppm background was also analyzed. For both 9 ppm standards analyzed, the number of residual non-attainment areas and control costs increased slightly. This is simply because a slightly greater emission reduction would be required to attain the standards. For the higher standards, there is no change in non-attainment areas, and costs decrease due to increased use of TCM with high fuel savings.

3.4.4 Case #5: 40 percent Maximum I/M Stringency

The primary case puts a 30 percent limit on the number of cars that are assumed to fail an I/M program. It is theoretically possible to fail more cars; one such possibility is to fail 40 percent of them in those areas that do not attain with a 30 percent stringency program. The 40 percent failure rate, selectively applied, comprises the essence of Case #5.

This change reduces residual non-attainment areas somewhat. For the 9 ppm, 2nd-high standard, the change results in 3 fewer non-attaining areas in 1987; there is no difference in 1990 and 1995 non-attaining areas. For most of the standards analyzed, the change results in substantially increased control costs. For the 9 ppm standards, this increase is about 9 percent; it is 11 percent for the 15 ppm standard.

3.4.5 Cases #6 and 7: 50 and 100 percent I/M Effectiveness

As discussed in 3.3.1, the primary case used a linear relationship between 50 percent effectiveness at 50°F and below (applied as a step-function), and 100 percent effectiveness at all temperatures. For Case 6, slight increases in non-attainment and decreases in costs are observed. This minimal difference would be expected since the step function closely approximates the primary case. The increased I/M effectiveness in Case 7 results in significantly reduced non-attainment and control costs, as shown in Tables 3-8 through 3-13.

3.5 Incremental Costs of CO Control*

Costs presented in previous sections represent the portion of mobile source control costs allocated to CO emission control as opposed to total program cost. Tailpipe emission control systems as well as in-use programs such as I/M provide for simultaneous control of more than one pollutant. Thus, the most accurate indication of CO control program costs is obtained from an allocation of costs among multi-pollutant programs.

Nonetheless, presentation of the incremental costs of CO control is also informative from the standpoint of those costs resulting directly from setting an ambient air quality CO standard. In this case, costs of programs or portion of programs where CO control is the sole emphasis are isolated. Programs which are implemented for control of other pollutants and which are required regardless of the need for CO control are not considered. The following discussion presents incremental costs for controlling CO through FMVCP as well as through I/M and TCM programs.

*This section deals in a partial sense with reversibility of control costs associated with systems designed to reduce HC and NO_x emissions, as well as CO emissions. It is not meant to describe total incremental costs for the alternative standards.

3.5.1 Incremental Costs of FMVCP

Estimating costs of controlling CO only through the FMVCP is exceedingly difficult. Since control of CO, HC, and NO_x has been mandated simultaneously, all FMVCP system costs represent control of all three pollutants. Little attention has been given to the situation of assessing the configuration and costs of control systems given the premise that CO control is not required. Because of the lack of pertinent data, the assumption is made that the three-way catalyst would be used in future technology cars (1981 and later) even without CO control requirements.

However, inclusion of the oxidation catalyst in combination with the three-way catalyst can be attributed solely to the requirement of controlling CO to the statutory limit of 3.4 grams/mile. Hence, the incremental costs of CO control resulting from FMVCP can be viewed as the cost of requiring oxidation catalysts on future technology cars. Based on information from auto manufacturers as well as independent sources, EPA estimates that adding an oxidation clean-up catalyst to a three-way catalytic converter ranges from \$9 to \$21 per auto (see Appendix A). Using the approach outlined in Appendix A for determining annualized hardware costs, the fleet-wide annualized costs for a 3.4 FMVCP will be about from \$2,000 million in 1987 and \$2,600 million in 1995. This takes into account hardware costs only and does not assume any maintenance or fuel benefits or penalties associated with the oxidation catalyst.

3.5.2 Incremental Costs of I/M and TCM

While the majority of areas that will be implementing I/M programs experience both ozone and CO problems and thus need control of both HC and CO, several areas have just a CO problem. While these areas also receive benefits of HC control from I/M programs, the programs are instituted primarily because of the needs for CO control. As a result, the incremental costs of I/M for CO control represent total program costs in these areas. These areas include those with current plans to institute programs for I/M that are designated as

non-attainment for CO only, as well as areas identified in this analysis as possibly needing I/M programs for CO in the future but which are not currently designated non-attainment.

Using this approach for determining incremental CO control requirements, 13 areas in 1987 could need an I/M program for CO only under a 9 ppm, 2nd-high standard. In these areas, gross I/M costs are estimated to be \$19 million (in constant 1984 dollars); net I/M costs are estimated to be around \$18 million, assuming fuel benefits are associated with the program.

The incremental cost of TCM for CO cannot be estimated readily because of the variability of the effectiveness of similar strategies of HC and CO. An area-wide program implemented to combat an ozone problem may not necessarily alleviate an area's CO problem, particularly if the problem area is a hot spot. However, if it is assumed that (1) all TCM measures are equally effective for HC and CO in areas with both a CO and ozone problem, and (2) TCM measures do not provide any ozone benefits in areas that do not attain the CO standard only, then certain cost calculations can be made. Given these assumptions, the costs of TCM programs are assumed to be split equally for areas not attaining the CO and ozone NAAQS, and allocated solely to CO for TCM costs (and savings due to fuel benefits) in CO-only non-attaining areas. This results in 1987 CO incremental gross costs of \$65 million (in constant 1984 dollars) and net costs of \$17 million.

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4. STATIONARY POINT SOURCE CONTROL

This section presents the costs of stationary point source control requirements to meet alternative CO ambient air quality standards. The sources were examined in isolation, using an assumed background CO level of 2 ppm. The control requirements and costs were selected to meet the ambient standard at the lowest annualized cost of control including any steam credit obtained from burning CO. A complete description of the methodology used and assumptions made in this simulation is presented in Appendix B. Appendix B has been left unchanged from previous analyses, and thus contains some references which do not apply to the standards currently under consideration (e.g. 5 expected exceedance forms). The contents of this section also have been reviewed and updated from previous analyses.

4.1 STATIONARY POINT SOURCE COSTS

Tables 4-1 and 4-2 present the results of modeling and costing procedures. Each table indicates the number of facilities which require control under alternative CO NAAQS. Costs are presented in 1984 dollars and reflect the total initial capital cost and the annualized cost for a 1987 attainment date. It should be noted that the results shown here are also applicable to attainment dates in 1990 and 1995 due to the exclusion of growth (see Appendix B.4) and retirement. The latter would tend to reduce costs for existing sources as it would deplete the existing source inventory to some degree. Lacking information on equipment age, the assumption was made that the equipment population would remain static; that is, retirement of obsolete equipment would not occur during the period of concern.

TABLE 4-1
CAPITAL COSTS FOR STATIONARY POINT SOURCES, BY INDUSTRY:
EIGHT-HOUR ALTERNATIVE CO STANDARDS
(1984 \$10³)

SIC	Industry	Number of Controlled Sources				Capital Costs of CO Control			
		7 ppm	9 ppm	12 ppm	15 ppm	7 ppm	9 ppm	12 ppm	15 ppm
2865	Maleic anhydride	3	2	2	1	\$ 2,600	\$ 1,560	\$ 2,420	\$ 780
2895	Carbon black	12	11	6	4	36,500	32,400	18,650	12,330
3312	Steelmaking	2	1	1	0	29,300	6,030	6,700	0
3321	Gray iron	18	12	4	1	380	230	70	20
3334	Primary aluminum	2	2	2	1	43,840	43,840	43,840	21,920
3711	Automobile manu- facturing	1	0	0	0	30	0	0	0
4953	Incineration	1	1	1	1	7	7	7	7
	TOTAL ^a	39	29	16	8	\$ 112,700	\$ 84,070	\$ 71,700	\$ 35,060

^aFigures may not sum due to rounding.

TABLE 4-2
ANNUALIZED COSTS FOR STATIONARY POINT SOURCES, BY INDUSTRY:
EIGHT-HOUR ALTERNATIVE CO STANDARDS
(1979 \$10³)

SIC	Industry	Number of Controlled Sources				Annualized Costs of CO Control			
		7 ppm	9 ppm	12 ppm	15 ppm	7 ppm	9 ppm	12 ppm	15 ppm
2865	Maleic anhydride	3	2	2	1	\$ -550	\$ -220	\$ -1,890	-110
2895	Carbon black	12	11	6	4	-18,270	-16,450	-8,870	-5,860
3312	Steelmaking	2	1	1	0	-12,650	-320	-3,150	0
3321	Gray iron	18	12	4	1	560	410	110	50
3334	Primary aluminum	2	2	2	1	43,840	43,840	43,840	21,920
3711	Automobile manu- facturing	1	0	0	0	90	0	0	0
4953	Incineration	1	1	1	1	7	7	7	7
	TOTAL ^a	39	29	16	8	\$ 13,030	\$ 27,270	\$ 30,050	16,000

^aFigures may not sum due to rounding.

4.1.1 Attainment of a 9 ppm Eight-Hour Standard

4.1.1.1 Costs

Attainment of an eight-hour 9 ppm standard results in a capital expenditure of almost \$84 million (see Table 4-1) and an annualized cost of \$27.3 million (see Table 4-2). Three industries incur positive annualized costs: primary aluminum amounts to \$44 million, followed by gray iron with \$410,000 and incineration with \$7,000. The bulk of the negative annualized cost stems from carbon black, which accounts for \$16.5 million in annualized savings. Steel incurs an annualized savings of \$320,000 and maleic anhydride would save \$220,000.

4.1.1.2 Tonnage Reduction

Table 4-3 shows the degree of CO emission reduction under alternative eight-hour standards. The eight-hour 9 ppm standard results in 964,100 tons of reduction, over 75 percent of which is produced by the carbon black industry. Steel accounts for 9 percent of the reduction; gray iron represents 8.5 percent of the reduction (82,000 tons); and primary aluminum accounts for 4.4 percent (42,000 tons).

4.1.2 Attainment of Alternative Eight-Hour Standards

4.1.2.1. Costs

The capital cost required by industry under the alternative eight-hour standards (Table 4-1) indicates that a 34 percent increase is caused by the 7 ppm alternative. The most significant increases under 7 ppm occur for maleic anhydride (67 percent), steelmaking (386 percent), and gray iron (65 percent). The 7 ppm standard shows a positive annualized cost (Table 4-2) for four industries: gray iron, primary aluminum, automobile manufacturing, and incinerators. The largest increase in cost occurs in the gray iron industry. This happens since 50 percent more sources must control than under either 9 ppm standard (2nd-high or one expected exceedance).

TABLE 4-3
 TONS OF CO REDUCTION, BY INDUSTRY: EIGHT-HOUR ALTERNATIVE CO STANDARDS
 (10³ tons)

SIC	Industry	Eight-hour Alternative CO Standard			
		7 ppm	9 ppm	12 ppm	15 ppm
2865	Maleic anhydride	29.8	21.8	15.8	12.0
2895	Carbon black	853.9	729.0	443.0	363.0
3312	Steelmaking	157.0	88.0	19.0	0.0
3321	Gray iron	105.9	82.3	17.6	9.1
3334	Primary aluminum	42.0	42.0	42.0	22.0
3711	Automobile manufacturing	16.0	0.0	0.0	0.0
4953	Incineration	1.0	1.0	1.0	1.0
TOTAL		1208.6	964.1	538.4	407.1

Three industries--maleic anhydride, carbon black, and steelmaking--provide negative annualized costs sufficient to reduce the annual cost to \$13.0 million compared to the \$27.3 million under the 9 ppm standard.

Under a relaxed alternative eight-hour standard of 12 ppm, the total capital expenditure decreases by 14.7 percent. Relaxation of the standard for both maleic anhydride and steelmaking under the 12 ppm standard increases capital expenditure but decreases annualized costs. This happens because the control strategies which may be used to comply with a 12 ppm standard provide a greater benefit in terms of fuel savings. This control strategy removes less CO, however (see Table 4-3), and therefore could not be used for the 7 or 9 ppm standards. Three industries show positive annualized cost for the 12 ppm standard: primary aluminum, gray iron, and incinerators. Under the 12 ppm standard, however, the total annualized cost increases by 10 percent. Again, this happens because the reduced stringency eliminates some control on carbon black which provided a net savings of \$7.6 million. Under a 15 ppm standard, capital costs and annualized costs drop to about 42 and 59 percent of those for 9 ppm, principally due to elimination of controls at one primary aluminum plant.

4.1.2.2 Tonnage Reduction

The reduction in CO emissions attributable to the alternative standards is shown in Table 4-3. The 7 ppm alternative results in a 25 percent incremental reduction over the current standard. This alternative represents the most restrictive concentration level of any standard as indicated by the level of CO reduction achieved in response. The 12 ppm alternative reduces emissions by 538,400 tons from baseline levels and represents a 44.2 percent decrease from the reduction required to attain 9 ppm standards. A 15 ppm standard would require a total decrease of 407,100 tons, about 58 percent less than the reduction for 9 ppm.

REFERENCES FOR SECTION 4

PEDCo Environmental, Inc. (PEDCo). February 1979. "Control Techniques and Costs for Carbon Monoxide Emissions -- Interim Report #1."

5. MOBILE SOURCE ECONOMIC ANALYSIS

5.1 INTRODUCTION

The mobile source control costs presented in Section 3 consist of obligations to be paid by local governments or by individual car owners. The impact of these costs is analyzed in terms of their effect on these two sectors.

Four scenarios were chosen for economic analysis. They are the current 9 ppm 2nd high NAAQS, and the 9, 12 and 15 ppm alternative NAAQS for a 1 ex ex form of the standard. This analysis is performed for the primary case assumptions described in Section 3. Most of the numbers come from the previous CO cost economic analysis (EPA, 1982), updated to 1984.

It was assumed that the payments made by local government, primarily for initial investment of I/M and gross annual TCM costs, are paid directly from local government revenues. The relative ease or difficulty in paying the cost depends on the revenue received. The costs therefore are compared to typical government revenues for the localities involved. I/M programs, once developed, are typically designed to be self-supported by the user charge, or fee.

The costs paid by individual car owners, which include FMVCP, inspection, and I/M repairs, were calculated from average cost estimates. The impact of these costs on average individuals would be difficult to specify. In addition, the variance of costs around the average estimates is not known and could be more significant than the averages themselves.

Examination of costs borne by motorists may be more useful if performed across income levels, that is, by determining the relative burden on different economic classes of motorists. The fuel savings provided by I/M programs and TCM are examined in the same manner. Fuel savings can help reduce the net cost of the control programs to groups of motorists, but they are received by this portion of the population only and cannot be transferred to cover other costs. The lack of liquidity of costs and savings makes the economic analysis

not only a question of direct and indirect impacts, but also one of the progressive or regressive nature of costs. In other words, is the cost being paid by those individuals best able to pay, or is a disproportionate amount of the cost paid by lower income groups? It should be stressed that this analysis ignores benefits of control accruing to all income groups. Thus, it is unfair to just focus on cost burdens to different income groups. Even if the control requirements are regressive on net, they are consistent with the "polluter pays" principle.

5.2 ANALYTICAL PROCEDURE AND ASSUMPTIONS

5.2.1 Federal Motor Vehicle Control Program

Regardless of the ambient air quality standard level, the cost of FMVCP must be paid. FMVCP, while separate from the National Ambient Air Quality Standards (NAAQS) program, provides emission reductions necessary to attain a standard. In the absence of FMVCP, emission reductions provided by the program in a nonattainment area would have to be obtained through additional control measures.

Cost of the program (see Appendix A) is derived through control of four sectors: heavy-duty vehicles, light-duty vehicles, light-duty trucks, and motorcycles. There are no CO standards for aircraft. Most of the total annual cost of the program results from control of light-duty vehicles, light-duty trucks, and motorcycles. It is assumed that costs from these sectors are borne by owners of these vehicles. The costs then, can be divided by income group using automobile ownership information obtained from the Department of Transportation (DOT, 1974). It is assumed that ownership patterns for light-duty trucks and motorcycles are similar to those of light-duty vehicles.

FMVCP costs for heavy-duty vehicles comprise the remainder of the total cost of the program. It is assumed that most heavy-duty vehicles are used in industry or for commercial purposes. Because these costs are imposed on all heavy-duty vehicles, the cost of control can be passed through to the final

consumer. The relatively small magnitude of these costs, \$129 to \$207 million for all heavy-duty vehicles, depending on the analysis year, indicates that pass-through of costs would have virtually no measurable effect on the prices of the goods and services involved.

5.2.2 Inspection/Maintenance Program

5.2.2.1 Initial Capital Investment

The estimate of initial capital required to start an I/M program is dependent solely upon the number of cars inspected under the program. An average figure of \$18.1 per car generates the cost.

It is assumed that initial expenditure is made by the county government. Problems in budgeting and allocating the county funds are not considered in this analysis; instead, the initial investment is compared to total county revenues including transfers from Federal and State Sources. This provides an indicator showing any difficulties in meeting the capital requirements of the program at the extremes of county income levels.

5.2.2.2 Inspection Costs

Under an I/M program, all registered passenger vehicles would be inspected each year. For the main analyses, a fee of \$7.00 per vehicle is estimated to be the annualized cost of the inspection. This fee is assumed to cover the capital costs and operating expenses of the inspection and would be paid by the owner of the car.

The total inspection cost, therefore, can be divided into the income groups of car owners who pay for the inspection. The Department of Transportation statistics again are used to accomplish this. The resulting distribution of cost by income group is examined to determine where the burden of cost is heaviest. Although the average car owner pays \$7.00, this distribution does not tell what, if any, redistributive effect results from the program.

5.2.2.3. Repair Costs

Any automobile failing the inspection test is required to undergo maintenance, with the cost of repairs estimated in 3.2.1.2. Each State, in its State Implementation Plan (SIP) for attainment, will determine the test criteria for passing and failing the test. A given stringency factor (i.e., number of failures) can result in several emissions criteria for failure. For each State, test thresholds could be different.

Historically, even with this variation, there is a correlation between the age of the vehicle and failure rate. Data regarding this correlation were published by the Air Pollution Control Association (APCA, 1979). Using these data, a statistic indicating likelihood of failure by age was created. The probability of failure was divided by the probability of failure of a car of mean age (DOT, 1974). This age-failure index is presented in Table 5-1. The statistic then can be applied to any stringency factor to determine the increased or decreased probability of failure as a function of age.

A distribution of age of car by income of the owner was found in the National Personal Transportation Study (DOT, 1974). These data are presented in Table 5-2. For each income level and corresponding mean age of car, the table also shows the age-failure index, which is calculated by linear interpolation between years.

A distribution of repair costs is determined from these statistics by multiplying income group ownership by the corresponding age-failure index. The resulting distribution is normalized by dividing by the summation of the age-failure index times the percent of cars by income in order to indicate a distribution of cost. In functional form, the statistic is calculated as follows:

TABLE 5-1

AGE-FAILURE INDEX

Year	Percent Observed Failures	Index Observed ÷ Mean
----	-----	-----
1	55	0.836
2	49	0.745
3	60	0.912
4	69	1.049
5	70	1.064
6 and above	71	1.079
Mean	65.8	1.000

TABLE 5-2

DISTRIBUTION OF MOBILE SOURCE COST FACTORS

Income Group	Age	Age-Failure Index	Percent of Cars (%)	Age X Percent	Distribution by Income
-----	---	-----	-----	-----	-----
< 6,600	7.0	1.079	5.91	0.0638	0.0599
6,600-11,000	6.1	1.079	9.42	0.1016	0.0955
11,001-16,600	5.8	1.076	20.00	0.2150	0.2020
16,601-22,000	4.8	1.060	18.02	0.1910	0.1794
22,001-33,000	4.6	1.057	24.53	0.2593	0.2435
>33,000	4.0	1.049	12.50	0.1311	0.1232
Unreported	5.5	1.069	9.61	0.1027	0.0965

$$\frac{IG \times AF}{\star(IG \times AF)}$$

where

IG = Percentage of cars by income group

AF = Age-failure index

* = Summation over all income groups.

Each factor is presented in Table 5-2.

It should be noted that implicit within this calculation is the assumption that the mean failure rate of a car whose owner is part of a particular income group can be estimated by the failure rate of a car of mean age within that group. Strictly, this would be true only if the age distribution within each income group were normal. The resulting distribution therefore provides only an indicator of the burden of cost.

The normal distribution of repair cost is multiplied by the total repair cost for each scenario to indicate the relative burden of repair cost by income group.

5.2.2.4 I/M Fuel Savings

The fuel savings accrued by I/M programs are a direct result of the maintenance performed on vehicles that fail the emission test. The fuel savings benefit is received only by car owners that pay repair costs. The value of fuel savings can be divided using the same statistic created for the distribution of repair costs presented in the preceding section. The money saved by reduced fuel consumption is subtracted directly from the repair costs since the costs and savings are not independent.

5.2.3 Transportation Control Measures

5.2.3.1 Gross Annual Cost

The annual cost of TCM is assumed to be paid by the local county government (there is no direct charge to the motorist) and is treated as if it were paid by general county revenue. Since this is an annual cost, the revenue is assumed to meet the cost each year. It is possible that some portion of the cost could be paid by state or federal funds. Placement of the burden on the counties estimates the maximum possible impact for each county requiring TCM.

The average cost of control per county is compared to a range of county revenues obtained from the 1972 Census of Governments (Bureau of Census). The revenues were inflated to 1984 dollars using Federal Reserve Bank GNP deflators. This provides an indicator of the ability of a county to meet the obligation imposed by TCM annual costs.

5.2.3.2 TCM Fuel Savings

Fuel savings result from TCM by reducing the number of miles or hours traveled (see Section 3). The reduction in gasoline consumption is assumed to be constant per ton of CO reduced by TCM. This corresponds directly to the reduction in VMT. The fuel savings therefore are divided equally among all drivers on the basis of current VMT.

The National Personal Transportation Study (DOT, 1974) also provides data on the percent of total VMT travelled by each income group. Multiplying these percentages by the total value of TCM fuel savings under each scenario gives an estimate of the benefits of fuel savings to each income group.

5.3 ECONOMIC IMPACTS

5.3.1 Federal Motor Vehicle Control Program

Table A-11 shows the annual cost of FMVCP, with the total cost for passenger cars, light-duty trucks, and motorcycles equaling 3.1 billion in 1987.

Table 5-3 shows the estimated distribution of these costs by income group. Since this distribution is based on the percent of cars owned by each income group, the first column of the Table 5-3 also reflects the portion of FMVCP costs allocated to each group.

A previous analysis has shown that the marginal number of cars per increased dollar in income decreases with higher incomes. Thus, in proportion to household income, a low income household will face a larger burden from FMVCP than will a high income household. This reflects the necessity for lower income households to spend a greater proportion of their incomes on transportation. This does not imply that the total burden on the low income group is disproportionate to its segment of the population. For example, approximately 12.8 percent of all households earned less than \$6400 per year in 1979. By comparison, the same group paid only 10.6 percent of the total FMVCP. The result, therefore, indicates that there is no real additional burden to low income households as a group, although individual households within the low income group pay a substantially higher portion of their income for FMVCP than do individuals from higher income households. (U.S. EPA, 1982)

This impact is present with all other scenarios discussed. The cost distribution by income group presented will serve as a basis for comparison with the costs of the other control techniques.

TABLE 5-3

DISTRIBUTION OF FMVCP COSTS^a BY INCOME

Income Group	Percent of Cars (%)	Average Number of Autos per Household	1987 FMVCP Costs (\$10 ⁶)
< 6,600	5.9	0.4	185
6,600-11,000	9.4	0.8	294
11,001-16,600	20.0	1.1	622
16,601-22,000	18.0	1.3	551
22,001-33,000	24.5	1.6	750
>33,000	12.5	1.9	379
Unreported	9.6	1.2 ^b	297
Total			3,078

a - Costs for LDV's, LDT's, and motorcycles.

b - Mean number of automobiles per household.

5.3.2 Inspection/Maintenance Program

5.3.2.1 Initial Investment Cost

Table 5-4 presents estimated initial investment costs for I/M programs. The initial investment was estimated using a per-vehicle investment of \$18.1 and projected I/M area car counts in 1995. Costs for ozone NAAQS nonattainment areas were divided by two to allocate half of the investment to CO. Since the initial investment was determined by projected car counts, average county investment indicates that areas requiring I/M under the 9 ppm standards have smaller car counts than those still needing I/M under the 12 and 15 ppm alternatives. For counties with population of 100,000 or more, the average revenue is \$485 million per year (U.S. DOC, 1972). The range of initial investments per county in Table 5-4 represents between 0.5 and 2.0 percent of this average county revenue. Since revenues of areas requiring I/M for the 12 and 15 ppm standards will be higher than this average, it is expected that all counties will actually fall at the lower end of the range above.

5.3.2.2 Inspection Cost

Table 5-5 presents the distribution of inspection costs by income group for the scenarios under analysis. Since the distribution of cost is dependent upon the number of cars in each income group, the portion of the total inspection cost paid by each income group remains constant. Any fluctuation in cost of each inspection results from a change in the number of cars tested under the program.

As in the case of FMVCP, the inspection cost is regressive in nature. As income rises, there is a diminishing marginal increase in the number of cars owned by a household. Since the cost is directly proportional to the number of cars, the relative cost of inspection decreases for higher income levels. In simple terms, this indicates that a greater portion of the income of low income families is spent on inspection than that spent by higher income families. As pointed out for the FMVCP, this does not indicate that the

TABLE 5-4

INITIAL I/M INVESTMENT COST

(In constant 1984 dollars x 10⁶)

	Alternative NAAQS (ppm)			
	9/2nd High	9/1 ExEx	12/1 ExEx	15/1 ExEx
Initial Investment	316.2	278.4	69.9	55.2
Number of Counties	129	112	7	2
Average County Investment	2.5	2.5	10.0	27.6

TABLE 5-5

DISTRIBUTION OF I/M INSPECTION COSTS
FOR ALTERNATIVE NAADS (ppm)(In constant 1984 dollars x 10⁶)

Year :	1987					1990					1995				
	9/2nd High	9/1 ExEx	12/1 ExEx	15/1 ExEx		9/2nd High	9/1 ExEx	12/1 ExEx	15/1 ExEx		9/2nd High	9/1 ExEx	12/1 ExEx	15/1 ExEx	
NAADS:															
Income Group															
< 6,600	7.9	6.4	1.7	1.3		9.4	7.6	1.5	1.4		9.7	8.4	2.0	1.4	
6,600-11,000	12.7	10.2	2.8	2.1		14.9	12.2	2.5	2.2		15.4	13.4	3.2	2.3	
11,001-16,600	26.8	21.5	5.9	4.4		31.5	25.8	5.2	4.6		32.6	28.3	6.7	4.9	
16,601-22,000	23.8	19.1	5.2	3.9		28.0	22.9	4.6	4.1		28.9	25.2	5.9	4.3	
22,001-33,000	32.3	25.9	7.1	5.3		38.0	31.1	6.3	5.6		39.3	34.1	8.0	5.9	
>33,000	16.3	13.1	3.6	2.7		19.2	15.7	3.2	2.8		19.9	17.3	4.1	3.0	
Unreported	12.8	10.3	2.8	2.1		15.1	12.3	2.5	2.2		15.6	13.5	3.2	2.3	
Total	132.7	106.5	29.1	21.9		156.1	127.7	25.7	22.9		161.3	140.2	33.0	24.1	

proportional burden on the low income group as a whole is greater than their portion of the population. The additional burden is placed on the individual low income household with a car.

5.3.2.3 Repair Costs

Repair costs of the I/M programs are divided by income group using statistics created from the age-failure relationship (see Table 5-2). Results of these distributions of cost are presented in Table 5-6.

It should be remembered that the distribution of cost by income group represents a distribution based on historical failure rates. The actual costs distribution could differ from the estimates presented depending on the individual threshold values of emissions used to determine failure in each program.

The effect of increased failure in older cars tends to exacerbate problems of the low income group. As Table 5-2 shows, inclusion of the age-failure index causes the distribution of repair costs to be skewed towards low income groups compared to the original distribution of car ownership. The shift in distribution, while never more than 0.1 percent for any income group, adds to the adverse income distribution impact of mobile source costs. Again, the total burden on the low income group is not disproportionate; it is individual low income households that may be adversely affected.

Since the percentages calculated to distribute the repair costs are independent of the scenario analyzed, relative impacts among income groups is the same for all scenarios. The difference in absolute impacts is brought about by increases or decreases in program stringency and the number of counties in which programs are required.

TABLE 5-6

DISTRIBUTION OF I/M REPAIR COSTS
FOR ALTERNATIVE NAAQS (ppm)(In constant 1984 dollars x 10⁶)

Year :	1987					1990					1995				
	9/2nd High	9/1 ExEx	12/1 ExEx	15/1 ExEx	9/2nd High	9/1 ExEx	12/1 ExEx	15/1 ExEx	9/2nd High	9/1 ExEx	12/1 ExEx	15/1 ExEx	9/2nd High	9/1 ExEx	12/1 ExEx
Income Group															
< 6,600	6.8	5.3	1.5	0.9	7.0	5.5	1.2	0.8	6.4	5.1	1.3	0.7			
6,600-11,000	10.9	8.5	2.4	1.4	11.2	8.7	1.9	1.2	10.1	8.2	2.0	1.1			
11,001-16,600	23.0	17.9	5.1	2.9	23.6	18.4	4.0	2.6	21.5	17.3	4.3	2.3			
16,601-22,000	20.5	15.9	4.5	2.5	21.0	16.3	3.6	2.3	19.1	15.4	3.8	2.0			
22,001-33,000	27.8	21.5	6.1	3.5	28.5	22.2	4.8	3.1	25.9	20.9	5.2	2.8			
>33,000	14.0	10.9	3.1	1.7	14.4	11.2	2.5	1.6	13.1	10.6	2.6	1.4			
Unreported	11.0	8.5	2.4	1.4	11.3	8.8	1.9	1.2	10.2	8.3	2.1	1.1			
Total	114.0	88.5	25.0	14.2	117.0	91.0	19.9	12.7	106.2	85.8	21.3	11.4			

5.3.2.4 Fuel Savings for I/M

The fuel savings for I/M are related directly to the repairs performed on vehicles that fail inspection. Fuel savings therefore can be distributed among income groups using the same percentages used to distribute repair costs. Table 5-7 presents results of this distribution of fuel savings.

Since fuel savings occur directly from maintenance, the value of these savings can be subtracted directly from the repair cost to estimate a total cost of repair. In all cases, the amount of fuel savings for each income group exceeds the corresponding repair cost. The total annual impact of repairs including fuel savings is a net savings. Table 5-8 presents these net savings for each income group.

The statistical nature of the repair cost and fuel savings (i.e., using average costs for each without a distribution of costs) makes it impossible to guarantee that every car owner who requires repair will receive a net savings. There is no assurance of a balance between repair costs and fuel savings for each motorist. A motorist might be stuck with a repair bill and no fuel savings. However, in terms of the macroeconomic impact, the combined fuel savings and repair costs provide a greater savings in proportion to income for low income groups than for high income groups.

5.3.3 Transportation Control Measures

5.3.3.1 Gross Annual Cost

TCM's are necessary in a relatively few number of counties compared to I/M programs. The number of counties requiring this kind of control ranges from 36 for the 9 ppm/second-high standard to 1 for the 15 ppm/l expected exceedance alternative, using the primary case assumptions. The average gross annual cost per county ranges from \$11.4 million for the 9 ppm/l expected exceedance alternative in 1987 to \$0.4 million under the 15 ppm/l expected exceedance option in 1995. Results for all scenarios are presented in Table 5-9.

TABLE 5-7

DISTRIBUTION OF FUEL SAVINGS FROM I/M
FOR ALTERNATIVE NAADS (ppm)(In constant 1984 dollars x 10⁶)

Year :	1987				1990				1995			
	9/2nd High	9/1 ExEx	12/1 ExEx	15/1 ExEx	9/2nd High	9/1 ExEx	12/1 ExEx	15/1 ExEx	9/2nd High	9/1 ExEx	12/1 ExEx	15/1 ExEx
Income Group												
< 6,600	0.8	0.6	0.2	0.1	1.5	1.2	0.3	0.2	2.1	1.7	0.4	0.2
6,600-11,000	1.3	1.0	0.3	0.2	2.4	1.9	0.4	0.2	3.4	2.7	0.7	0.4
11,001-16,600	2.8	2.2	0.6	0.3	5.2	4.0	0.9	0.5	7.1	5.7	1.4	0.7
16,601-22,000	2.5	1.9	0.6	0.3	4.6	3.5	0.8	0.5	6.3	5.1	1.3	0.7
22,001-33,000	3.4	2.6	0.8	0.4	6.2	4.8	1.0	0.6	8.6	6.9	1.7	0.9
>33,000	1.7	1.3	0.4	0.2	3.2	2.4	0.5	0.3	4.3	3.5	0.9	0.5
Unreported	1.4	1.0	0.3	0.2	2.5	1.9	0.4	0.3	3.4	2.7	0.7	0.4
Total	14.0	10.8	3.1	1.6	25.6	19.7	4.3	2.6	35.2	28.3	7.1	3.7

TABLE 5-8

DISTRIBUTION OF NET 1/M REPAIR COSTS AND FUEL SAVINGS
FOR ALTERNATIVE NAADS (ppa)

(In constant 1984 dollars $\times 10^6$)

Year :	1987					1990					1995				
	9/2nd High	9/1 ExEx	12/1 ExEx	15/1 ExEx	9/2nd High	9/1 ExEx	12/1 ExEx	15/1 ExEx	9/2nd High	9/1 ExEx	12/1 ExEx	15/1 ExEx	9/2nd High	9/1 ExEx	15/1 ExEx
NAADS:															
Income Group															
< 6,600	6.0	4.7	1.3	0.8	5.5	4.3	0.9	0.6	4.3	3.4	0.9	0.5	4.3	3.4	0.9
6,600-11,000	9.6	7.4	2.1	1.2	8.7	6.8	1.5	1.0	6.8	5.5	1.4	0.7	6.8	5.5	1.4
11,001-16,500	20.2	15.7	4.4	2.5	18.5	14.4	3.2	2.0	14.3	11.6	2.9	1.6	14.3	11.6	2.9
16,601-22,000	17.9	13.9	3.9	2.3	16.4	12.8	2.8	1.8	12.7	10.3	2.5	1.4	12.7	10.3	2.5
22,001-33,000	24.4	18.9	5.3	3.1	22.3	17.4	3.8	2.5	17.3	14.0	3.5	1.9	17.3	14.0	3.5
>33,000	12.3	9.6	2.7	1.6	11.3	8.8	1.9	1.2	8.7	7.1	1.7	0.9	8.7	7.1	1.7
Unreported	9.7	7.5	2.1	1.2	8.8	6.9	1.5	1.0	6.9	5.5	1.4	0.7	6.9	5.5	1.4
Total	106.0	77.7	21.9	12.6	91.4	71.3	15.6	10.1	71.0	57.5	14.2	7.7	71.0	57.5	14.2

TABLE 5-9

ANNUAL TCM GROSS COST FOR
ALTERNATIVE NAAGS (ppm)(In constant 1984 dollars x 10⁶)

Year :	1987					1990					1995				
NAAGS:	9/2nd High	9/1 ExEx	12/1 ExEx	15/1 ExEx	9/2nd High	9/1 ExEx	12/1 ExEx	15/1 ExEx	9/2nd High	9/1 ExEx	12/1 ExEx	15/1 ExEx			
Costs	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----			
Total	291.5	205.4	22.6	0.5	253.2	163.6	19.1	0.5	222.4	144.4	16.2	0.4			
County Average	10.1	11.4	7.5	0.5	7.0	7.8	6.4	0.4	6.2	6.9	5.4	0.4			
Average Percent of County Revenue by Population (Y):	-----														
100,000 - 250,000	6.7	7.6	5.0	0.3	4.7	5.2	4.3	0.3	4.1	4.6	3.6	0.3			
Mean County	14.4	16.3	10.7	0.7	10.0	11.1	9.1	0.6	8.9	9.9	7.7	0.6			

Gross costs are assumed to be paid by county governments. The average gross cost per county is calculated as a percentage of the total revenue for a range of county sizes. This provides an indication of the difficulty involved in paying the TCM cost. Table 5-9 displays these values. According to the Census of Governments (DOC, 1972), average county revenue is estimated at \$150 million for counties of 100,000 to 250,000 people, and \$70 million for all counties.

Some small counties could have considerable problems in paying for TCM without Federal assistance. If a small county with revenue on the low end of the range is forced to implement TCM, the cost could consume so much revenue that it would make continuation of county services practically impossible without additional revenue. A cost of \$11.4 million corresponds to a tax increase of \$174 per person using an average county population of 65,181 people (DOC, 1972). Examination of county population indicates that none of the counties thought to need TCM have populations of less than 50,000. Therefore, while there is some potential for problems in affording TCM, it does not appear to be overly burdensome to any county, especially since TCM projects are funded largely by the U.S. Department of Transportation's transportation system management program.

5.3.3.2 TCM Fuel Savings

Fuel savings accrued under TCM cannot be used to offset the cost of control measures since no tax revenue can be gained. The savings are received directly by the motorist. It is assumed that savings are proportional to VMT traveled. Table 5-10 shows the distribution of TCM fuel savings (at a \$1.20 per gallon fuel cost) using the percent of VMT traveled by income group.

Because of a lack of sufficient data points indicating the VMT per household by income class (only four points), it is impossible to make a meaningful estimate of the marginal increase in VMT by income. Without these data, the total effect of distribution of income as a result of TCM fuel savings cannot be estimated.

TABLE 5-10

DISTRIBUTION OF TCM FUEL SAVINGS
FOR ALTERNATIVE NAAQS (ppm)(In constant 1984 dollars x 10⁶)

Year 1	1987					1990					1995				
	9/2nd High	9/1 ExEx	12/1 ExEx	15/1 ExEx	9/2nd High	9/1 ExEx	12/1 ExEx	15/1 ExEx	9/2nd High	9/1 ExEx	12/1 ExEx	15/1 ExEx	9/2nd High	9/1 ExEx	15/1 ExEx
Income Group															
< 6,600	23.2	17.0	1.7	0.4	21.6	15.2	1.5	0.3	18.7	13.3	1.2	0.3	18.7	13.3	1.2
6,600-11,000	37.0	27.1	2.7	0.6	34.4	24.2	2.3	0.5	29.9	21.3	2.0	0.4	29.9	21.3	2.0
11,001-16,600	78.3	57.4	5.7	1.2	72.7	51.2	4.9	1.0	63.2	45.0	4.1	0.9	63.2	45.0	4.1
16,601-22,000	69.6	50.9	5.1	1.1	64.6	45.4	4.3	0.9	56.1	40.0	3.7	0.8	56.1	40.0	3.7
22,001-33,000	94.4	69.1	6.9	1.5	87.6	61.7	5.9	1.3	76.2	54.3	5.0	1.1	76.2	54.3	5.0
>33,000	47.8	35.0	3.5	0.8	44.3	31.2	3.0	0.6	38.6	27.5	2.5	0.5	38.6	27.5	2.5
Unreported	37.4	27.4	2.7	0.6	34.7	24.4	2.3	0.5	30.2	21.5	2.0	0.4	30.2	21.5	2.0
Total	387.8	283.9	28.4	6.1	359.9	253.3	24.2	5.2	313.0	222.8	20.5	4.4	313.0	222.8	20.5

5.4 CONCLUSION

The results of the economic analysis indicate that no particular segment of the population is forced to pay a disproportionate amount of the total cost of mobile source control. Therefore, there are no significant adverse income distribution impacts.

The incremental nature of ownership of automobiles does indicate, however, that some individual households may face a disproportionate cost. This is due to the relatively small increase in numbers of automobiles owned by higher income households. (In other words, a constant portion of total income is not used to purchase more cars for all households.) As a result, a cost proportional to the number of cars may place additional burden on individual low income households.

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6. ECONOMIC IMPACT ON INDUSTRIAL POINT SOURCES

6.1 ECONOMIC ANALYSIS PROCEDURE

Section 4 presented aggregate capital and annualized costs for each industry along with the number of plants controlled under each standard. In this section the average cost per controlled plant to a company within the industry is estimated by dividing the total control cost by the number of plants controlling.

The control data are obtained from the previous 1979 analysis of economic impacts, updated to 1984 dollars. The industry financial statistics, production and other data with which these costs are compared have been left as presented in the 1979 analysis. Thus, for example, estimated 1984 capital costs are compared with capital expenditures in 1979 dollars which are based on several earlier years. Production statistics are also from non-uniform years. Thus the estimates of percentage of capital investment needed for CO control and other indices in this Section are believed to be somewhat inflated. This results in a conservative assessment of industry impacts.

6.1.1 Data and Data Adjustments

6.1.1.1 Cost Data

The average annualized cost figures for plants requiring control must be altered to account properly for the effect of taxes. In their present form the figures represent the sum of operating costs, capital charges, and credits obtained from the use of CO as a fuel. Operating costs are the day-to-day expenditures required to operate the system. Capital charges are those items associated with owning the equipment, including depreciation, property taxes, insurance, and interest on borrowed capital. A uniform capital recovery factor

of 13.6 percent was chosen to estimate the effect of depreciation and interest (PEDCo, 1979). This portion of the capital charge is assumed to represent the only after-tax expense of owning the equipment. All other portions of the annualized cost represent before-tax expenses.* The cost of insurance, property taxes, and operating cost are deductible for tax purposes; thus, the magnitude of these costs is reduced by 48 percent, the corporate income tax rate.

Steam credits produced by heat recovery represent an income stream into the firm and are therefore taxable. This is true regardless of whether the steam is sold or used to reduce energy expenditures. The credits, therefore, must also be reduced by 48 percent. The tax-adjusted components of annualized cost then, were added again to represent the average after-tax cost of regulation to firms within each industry.

6.1.1.2 Financial Data

In addition to the cost data, financial data collected to construct a profile of the industries were used to determine the impacts. The data form a set of "typical" firms in each industry.

Financial characteristics of firms in four major industries -- primary aluminum, carbon black, gray iron, and maleic anhydride -- were compiled in order to present a composite picture of the capital structure of each industry. The primary sources of this information were Moody's Industrial Reports (1979) and the Value Line Investments Survey (Bernhard, 1979), with background material on the industry provided by the U.S. Department of Commerce, 1979 U.S. Industrial Outlook.

Production figures for the companies were used to determine typical size, while long-term debt, current liabilities, total stockholders' equity, and 1977 or 1978 capital investments were used to measure the financial strength

*Some financial analysts may disagree. For example, the uniform capital recovery factor could yield a stream of rental payments that is a before-tax expense item. Moreover, there is no room for investment tax credits and rapid write-off considerations using this approach.

of an average company in each industry. Also collected were debt/equity ratios and beta values; the latter are estimators of risk as measured by the covariance between stock market activity and company stock prices. These figures are used by investors to determine whether or not an investment in a company is wise. As such, they serve to indicate whether it would be difficult to generate capital.

Where data were available for most of the firms within an industry, the mean of the values collected was used to represent a typical firm. In other instances, the data collected were used to establish a range within which a typical firm would fall. For example, the gray iron industry comprises 1300 separate companies, but data are available for only a few of each size; therefore, the range of data collected established a range within which any firm is likely to fall.

6.1.2 Capital Availability Analysis

The following steps were used to determine the ability of a firm to shoulder the burden of capital expenses incurred by pollution control requirements:

- (1) screening for industries significantly affected;
- (2) comparing capital required to historical capital expenditures of a typical company;
- (3) comparing capital cost to total long-term debt of a typical company;
- (4) examining debt/equity ratios and beta values to determine the ability of a typical company to raise additional capital.

Screening consisted of examining the capital requirements for 1) the number of sources requiring control, and 2) the percentage of recent capital expenditure represented by controls under the most stringent standards. If the number of sources was limited (e.g., one plant) and capital costs were less than one percent of recent expenditures, the industry was removed from the study. (Fluctuations of one percent and less were assumed to be normal.) However, an industry comprised mostly of small firms was retained in the study since smaller changes in cost can affect small companies more significantly.

The percentage of recent capital expenditure represented by the control cost was then used to determine whether large amounts of additional capital need be raised or whether other investments would be delayed.

Capital costs were also compared to total long-term debt to indicate the ability of a company to absorb the expense. Small changes in debt would not affect the posture of a firm; large changes were examined for the effect on the debt/equity ratio. An increase in the debt/equity ratio or an already high ratio together with a high beta value indicates that raising capital may prove difficult.

6.1.3 Annualized Cost Impact Analysis

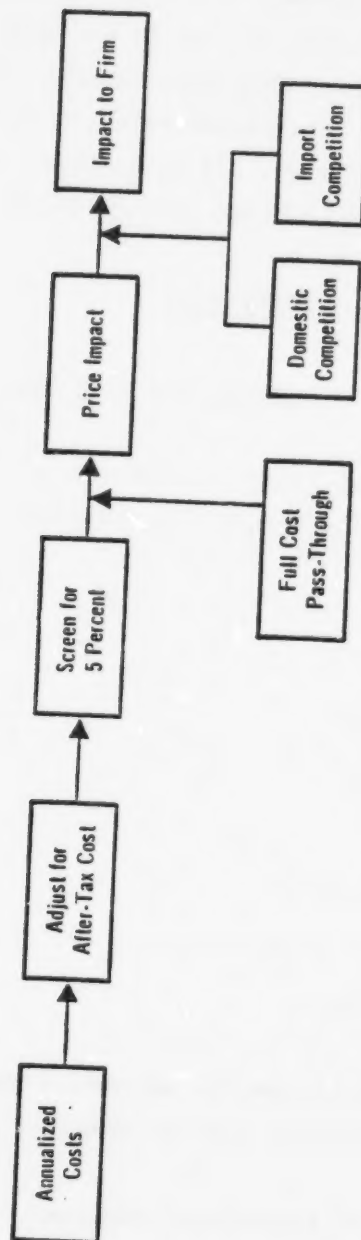
Figure 6-1 presents a diagram of the components of the annualized cost analysis. A screen for significant impact within the industries was used to eliminate industries whose price impact was less than 5 percent. Five percent was chosen for consistency with EPA "Criteria for Conducting Regulatory Analysis" (44 Federal Register 30988. (May 29, 1979)).

The average cost impact was calculated by dividing the tax-adjusted aggregate annualized cost for each industry by the number of sources controlled under each standard. It is assumed that this cost is representative of the cost faced by a typical firm.

By further assuming full pass-through of cost, the increase in the average cost of production cost would be offset by increases in price. Accounting for the effect of taxes (since 48 percent of the marginal revenue goes to corporate income tax), the price impact is approximately twice the increase in the average cost of production. The magnitude of the cost impact, viewed in terms of a percentage price increase, can be identified by comparing the price increase to a weighted average product price.

The price impact was examined to determine if there would be interference with the firm's competitive posture within its own industry. Foreign competition, transportation cost, and availability of sources of substitute products were considered within this effort.

FIGURE 6-1
ANNUALIZED COST METHODOLOGY



Because credits may be obtained by incineration and heat recovery, the annualized cost can be negative; that is, the value of the heat recovered (in steam) exceeds the annual cost of equipment operation. In these cases, the pollution control investment has been viewed as an exogenous investment; any benefits obtained are distributed to the shareholders and not reflected in a product price decrease. This conservative estimate is consistent with the economic theory that "the dollar price of goods and services resists being pushed down" (Solow, 1979). It is assumed, therefore, that corporations simply would not pass the cost savings on to the consumer.

6.2 ECONOMIC IMPACT TO INDUSTRY

6.2.1 Determination of Industries with Significant Impact

The regulatory impact analysis indicated that seven industries would require control under any alternative 1 ex ex NAAQS investigated in this report. They are:

- Maleic anhydride
- Carbon black
- Steelmaking
- Gray iron
- Primary aluminum
- Automobile manufacturing
- Incineration.

The latter two industries, at maximum, show only one source controlling even under the most stringent 1 ex ex standard (i.e., 7 ppm).

The maximum capital expenditure incurred by the automobile manufacturing industry is \$26,000 under any alternative. This amount is insignificant compared to investments made within the industry. General Motors, for example, invested \$4.6 billion in 1978. Even for the much smaller American

Motors Corporation, the \$26,000 would represent less than 0.5 percent of the \$41,233,000 invested in 1978.* The annualized cost of control to automobile manufacturing is \$90,000. While the figures are not readily available, it seems safe to assume that the operating budget of a company is not less than its capital investments. Therefore, even for the small automotive corporation, the cost increase would be less than 0.02 percent.

The most stringent standard requires control of CO emissions from one municipal incinerator. Both the capital and the annualized cost of control are approximately \$7,000. Since the incinerator is operated by a State or local government, the increased expenditure would come from governmental revenues. The aggregate of local government revenues across the United States for 1977 was \$105 billion. Wyoming, with \$170 million, ranked last in revenues received. Individual counties had revenues ranging from \$1.7 million to \$29 million (EEA, 1979). A \$7,000 expense represents only 0.41 percent of the smallest county revenue. Therefore, because of control requirements, incineration is considered not to have a significant impact.

6.2.2 Profile of Industries Facing Regulatory Impacts

6.2.2.1 Maleic Anhydride

Seven companies produce 117 gigagrams (10⁹ grams) of maleic anhydride annually at eight separate plants. The corporations have a mean debt/equity ratio of 31.9 percent and mean beta value of 0.96. For five of the companies 78 capital expenditures data were available. Three of the companies are large integrated corporations showing capital expenditures in excess of \$500 million per company. Two smaller corporations' expenditures were investments for chemical production alone, not for the entire corporation, and these were around \$33 million each.

*Telephone interview with staff of Automotive Information Council.

6.2.2.2 Carbon Black

Carbon black, an organic compound often used as reinforcing compound in rubber and plastic products, is produced by nine companies; financial data were available for six companies whose aggregate production is approximately 4.3 billion pounds per year. The corporations producing carbon black have a mean debt/equity ratio of 30.5 percent and a mean beta value of 0.97. In 1977, four of these companies invested more than \$1.7 billion in capital expenditures, about \$440 million each. The industry is associated with the petroleum refining industry by ownership and is concentrated in Louisiana, Texas, and Oklahoma.

6.2.2.3 Steel

The steelmaking industry was profiled using 10 of its largest firms, which account for almost all of the steel produced in the United States (97.1 million tons in 1978). The 10 companies have a mean debt/equity ratio of 31.9 percent, with the median at 34.5 percent. The mean beta value for steel companies is 0.99, indicating that, historically, return on steel investments has been almost identical to that of the market as a whole. The 1977 capital expenditures of these companies ranged from a low of \$30.2 million to a high of \$865 million, with a mean of \$236.5 million.

6.2.2.4 Gray Iron

It is difficult to describe a typical gray iron company because of the vast numbers and varieties of plants. Gray iron is produced at over 1300 U.S. foundries, ranging from giant casting foundries owned by auto manufacturers to small, family owned and operated foundries.

A representative cross section was drawn from the Iron Casting Society's Source Book. A wide variation was noted in the data collected for five companies ranging in size from 100 to 9000 tons per month. The debt/equity ratio ranged from 15 to 80 percent with no correlation to size; in fact, the two largest companies set the limits to the range.

Four of the companies were able to provide annualized cost data on pollution control equipment presently installed to control other nonspecified pollutants. They range from \$7500 to \$800,000 per year with the larger values occurring in the larger firms. This range will be compared with required expenditure to indicate increased burden.

Total 1977 capital expenditures for all investments ranged from \$60,000 to \$24,000,000. The latter figure could be a one-year anomaly since it is far greater than any of the other firms; \$300,000 is a more reasonable upper limit.

6.2.2.5 Aluminum--Primary Smelting

According to the Aluminum Association, primary aluminum is produced by 12 companies in 32 locations across the country. Approximately 5.19 million short tons of aluminum were produced in 1978. Financial information was available for 9 companies which account for 75 percent of the total or an average production rate of 432,800 tons per year per company. The mean debt/equity ratio is 38 percent, with a range of 23.17 to 54.7 percent and a median of 36.1 percent. Capital expenditures (1977) could be found for only three companies with values ranging from \$0.9 billion to \$1.7 billion.

Financial and production data gathered for the industries discussed in Section 6.2.2 are shown in Tables 6-1 through 6-5. All of the ratios, percentages, and price impacts shown in later sections of this chapter are derived from the data presented in these tables.

6.2.3 Capital Cost Impacts

6.2.3.1 Maleic Anhydride

Two sources in the maleic anhydride industry require control to meet either 9 ppm eight-hour standard. Compliance with these standards requires a capital expenditures of \$1.59 million, an average of \$780,000 for each plant. This represents less than 0.20 percent of the average 1977 capital investment

TABLE 6-1

MALEIC ANHYDRIDE: FINANCIAL PROFILE

Company	Annual Production ^{a/} (HG)	No. of Plants ^{a/}	Long-Term Debt ^{b/} (\$10 ³)	Stockholders Equity ^{b/} (\$10 ³)	Debt/Equity Ratio ^{b/} (%)	Total Capitalization ^{b/} (\$10 ³)	Beta Factor ^{c/}
1	15	1	\$2,007,379	\$6,840,594	27.0%	\$8,847,973	0.95
2	15	1	684,696	962,733	41.6	1,647,429	0.85
3	27	1	1,030,600	2,430,200	30.0	3,460,800	1.05
4	19	2	98,366	191,080	29.1	296,446	1.00
5	7	1	2,390,900	3,079,500	43.7	5,470,400	0.85
6	21	1	2,300,000	5,157,200	N/A	7,457,200	1.05
7	13	1	N/A	N/A	N/A	N/A	N/A

^{a/} EEA, Inc. 1979. "Estimate of Control Costs and Simulation of Markets in Emission and Air Quality Offsets in Nonattainment Areas."

^{b/} Hoody's Industrial Reports. 1979.

^{c/} Arnold Bernhard Co., Inc. June 1979. Value Line Investment Survey.

TABLE 6-2
CARBON BLACK: FINANCIAL PROFILE

Company	Plant Capacity (1977 10 ⁶ lb)	No. of Plants ^{b/}	Long-Term Debt ^{c/} (\$10 ³)	Total Stockholders Equity ^{c/} (\$10 ³)	Debt/Equity Ratio ^{c/} (%)	Total Capitalization ^{c/} (\$10 ³)	Capital Investment (\$10 ⁶)	Beta Factor
1	670	5	\$ 684,696	\$ 962,733	41.6%	\$1,647,429	\$401.0	0.85
2	912	5	124,978	284,675	30.5	409,653	N/A	1.00
3	1031	8	785,552	1,937,558	26.2	2,723,110	501.0	0.85
4	472	3	766,658	3,087,117	19.9	4,309,174	N/A	1.10
5 ^{a/}	427	4	1,066,074	2,880,397	27.2	3,946,471	584.4	1.10
6	130	1	387,000	651,400	37.3	1,038,400	174.8	0.90

^{a/}Data given are for a parent corporation which owns more than 60 percent of the company.

^{b/}FEA, Inc. 1979. "Estimate of Control Costs and Simulation of Markets in Emission and Air Quality Offsets in Nonattainment Areas."

^{c/}Hoody's Industrial Reports. 1979.

^{d/}Arnold Bernhard Co., Inc. June 1979. Value Line Investment Survey.

TABLE 6-3
STEELMAKING: FINANCIAL PROFILE

Company	Total Capacity Annual Production ^{a/} (1978 10 ⁶ tons)	No. of Plants ^{b/}	Long-Term Debt ^{b/} (\$10 ³)	Total Stockholders Equity ^{b/} (\$10 ³)	Debt/Equity Ratio ^{b,c/} (%)	Total Capitalization (\$10 ³)	Capital Investment (1977 \$10 ⁶)	Beta Factor
1	8.5	8	\$ 505,649	\$1,451,514	25.72%	\$1,957,163	\$146.4	0.92
2	18.8	8	140,800	2,248,200	34.62	2,399,000	532.1	1.20
3	8.6	1	613,979	1,145,580	34.92	1,759,559	282.0	0.80
4	1.1	N/A	85,233	324,926	31.01	410,159	30.2	0.90
5	2.3	1	77,845	464,834	34.62	296,452	32.4	0.95
6	1.9	4	135,892	160,560	42.01	542,679	117.3	1.15
7	10.5	3	406,416	1,285,864	36.10	1,692,280	161.7	0.75
8	10.0	10	452,252	1,334,029	25.32	1,786,281	155.5	1.05
9	31.3	N/A	2,300,000	5,157,200	20.01	7,457,200	865.0	1.05
10	4.1	2	209,220	283,082	35.01	492,302	45.1	1.20

^{a/}EEA, Inc. 1979. "Estimate of Control Costs and Simulation of Markets in Emission and Air Quality Offsets in Nonattainment Areas."

^{b/}Hoody's Industrial Reports. 1979.

^{c/}Arnold Bernhard Co., Inc. June 1979. Value Line Investment Survey.

TABLE 6-4

GRAY IRON FOUNDRIES: FINANCIAL PROFILE

Company	Total 1978 Production ^{a/} (net tons/month)	No. of Plants/ Foundries	Long-Term Debt/ b/ (\$10 ³)	Total Stockholders Equity b/ (\$10 ³)	Debt/Equity Ratio b/ (%)	Total Capitalization ^{b/} (\$10 ³)	Capital Expenditures b/ (\$10 ³)	Beta Factor
1	100	1	\$ 200.0	\$1,000	80%	\$1,200	\$250	N/A
2	500	1	1,000.0	1,600	100	2,600	275	N/A
3	1,000	1	240.0	3,000	15	3,240	N/A	N/A
4	500	1	323.9	697	40	1,000	60	N/A
5	9,000	1	23,000.0	71,000	80	94,000	24,000	N/A

^{a/} EEA, Inc. 1979. "Estimate of Control Costs and Simulation of Markets in Emission and Air Quality Offsets in Nonattainment Areas."

^{b/} Hoody's Industrial Reports, 1979.

^{c/} Arnold Bernhard Co., Inc. June 1979. Value Line Investment Survey.

TABLE 6-5

PRIMARY ALUMINUM: FINANCIAL PROFILE

Company	Primary Total Capacity (103 short tons)	No. of Plants (primary)	Long-term Debt c/ (\$10 ³)	Total Stockholders Equity c/ (\$10 ³)	Debt/Equity Ratio c/ (%)	Total Capitalization c/ (\$10 ³)	Beta d/ Factor
1	1,675.0	9	\$1,166,000	\$1,853,100	83.6%	\$3,019,100	1.10
2	975.0	7	736,503	994,414	42.6	1,732,917	1.30
3	724.0	N/A	677,500	N/A	N/A	1,530,200	1.25
4	352.0	2	N/A	4,983,245	N/A	N/A	N/A
5 ^{a/}	300.0	2	2,718,834	339,560	35.4	7,702,084	0.90
6	218.7	N/A	77,555	334,560	N/A	417,115	N/A
7	218.7	N/A	N/A	N/A	N/A	N/A	N/A
8	210.0	4	218,873	725,644	23.2	944,517	0.95
9	200.0	2	132,221	153,972	46.2	286,191	1.00
10	140.0	N/A	588,881	766,127	N/A	1,355,008	0.80
11	90.0	6	406,416	1,885,864	36.1	1,692,280	0.75
12	90.0	N/A	N/A	N/A	N/A	N/A	N/A

a/ Data given are for a parent corporation which owns more than 60 percent of the company.

b/ EEA, Inc. 1979. "Estimate of Control Costs and Simulation of Markets in Emissions and Air Quality Offsets in Nonattainment Areas".

c/ Hoody's Industrial Reports. 1979

d/ Arnold Bernhard Co., Inc. June 1979. Value Line Investment Survey.

for the companies. The cost represents only 24 percent of the smallest 1977 capital expenditure for any of the companies for which financial data were available.

The mean beta value for the firms producing maleic anhydride is 0.96, indicating both a slightly less-than-average risk associated with shareholders' investment and, combined with a debt/equity ratio of 31.9, a strong financial position. Even if the expenditures were all placed in long-term debt (i.e., 100 percent debt financed), it would represent only a 0.05 percent increase in debt.

Capital requirements for the maleic anhydride industry are shown in Table 6-6. The impact against 1977 expenditures (i.e., less than one percent in all cases), indicates little real problem with capital availability; the difference between 0.19 and 0.27 percent should not hinder the formation of capital.

6.2.3.2. Steelmaking

To meet either 9-ppm eight-hour standard, only one steelmaking plant must control CO emissions. The capital cost for the single plant is \$6.0 million. The mean value of capital expenditures in 1977 for the steel industry was \$236.5 million.

The control equipment capital cost, therefore, represents an average of 2.5 percent of the capital budget for typical corporations within the industry. In 1977, capital investments ranged as low as \$30.2 million for a single company. A \$6.0 million cost would represent 20.0 percent of the capital expenditure for that firm. However, assessing capital requirements in isolation can give misleading results. Chapter 4 shows that, on an annualized cost basis, CO control requirements result in a net cost savings, or credit.

Despite problems with competition from foreign steel products, the industry maintains a mean beta value of 0.99 and a relatively low debt/equity ratio of 31.9. This indicates that while expansion of the industry may not occur, its financial structure is reasonably sound.

TABLE 6-6
CAPITAL REQUIREMENTS FOR THE AVERAGE MALEIC ANHYDRIDE FIRM

<u>Alternative 8-Hour CO Standards</u>	<u>Capital Per Plant (\$10³)</u>	<u># of Plants Controlling</u>	<u>% of 1977 Capital Expenditure</u>	<u>% Increase in Long-Term Debt</u>
7 ppm	\$ 870	3	0.20	0.050
9 ppm	780	2	0.19	0.060
12 ppm	1210	2	0.30	0.080
15 ppm	780	1	0.19	0.060

Long-term debt for a typical steel producer is \$494 million. Total debt financing of the capital investment would be only a 1.2 percent increase in debt. Complete debt financing would raise the debt/equity ratio to 32.3, an increase of 0.4 percent.

6.2.3.3 Gray Iron

The 9 ppm eight-hour standards require 12 gray iron plants to control CO emissions at a capital cost of \$233,000, an average of \$19,400 per plant. This represents from 0.08 to 32.3 percent of the capital expenditures of foundries in 1977 (Company 2, Table 6-4). The expenditure represents 7.1 percent of the capital expenditures of our benchmark firm, and is 1.9 percent of the company's long-term debt.

Table 6-7 presents average capital costs for the gray iron industry. The percentage of 1977 capital expenditures is calculated from the expenditure of the benchmark firm. In the case of the gray iron industry, the effect on the individual firm of changing the standard is not very significant. The maximum difference between the capital requirements under any of the standards is \$3,500. The primary effect of a change is to alter the number of sources subject to the control requirements. Even so, the maximum number of plants involved (18) is less than one percent of the foundries in the United States.

6.2.3.4 Primary Aluminum

To meet either 9 ppm eight-hour standard, a capital expenditure of \$43.8 million is required for the control of two plants, an average cost of almost \$22 million per plant. Capital expenditure data for 1977 were available for only three companies which are of small size compared to the mean production of the industry. The figures for capital expenditure ranged from \$90 million to \$1.6 billion. This means that the capital required to

TABLE 6-7

CAPITAL REQUIREMENTS FOR THE AVERAGE GRAY IRON FIRM

<u>Alternative 8-Hour CO Standards</u>	<u>Capital Per Plant (\$10³)</u>	<u># of Plants Controlling</u>	<u>% of 1977 Capital Expenditure</u>	<u>% Increase in Long-Term Debt</u>
7 ppm	\$ 21.4	18	7.8	2.1
9 ppm	19.4	12	7.1	1.9
12 ppm	18.5	4	6.7	1.9
15 ppm	22.00	1	8.0	2.2

meet the eight-hour standard should represent between 1.4 and 24.4 percent of the capital investment in any year for these aluminum-producing companies. The cost is 3.3 percent of the average capital expenditure.

The mean value for debt is \$746.7 million, therefore, the control expenditure would be 2.9 percent of the total debt for the company. This might delay some other non-mandatory investments by requiring generation of equity to cover the expenditure. Capital expenditures are being considered at this stage of analysis in isolation of cost pass-through possibilities. Both capital expenditures and cost pass-through, or price impacts, must be considered in evaluating net impact on the primary aluminum industry.

Table 6-8 shows that average capital requirements for firms controlling for CO do not vary among standards.

6.2.3.5 Carbon Black

Capital investments for the corporations producing carbon black totaled between \$174.8 million and \$584.4 million in 1977, with a mean of \$440 million. The 9 ppm eight-hour standards requires control of 11 sources, which make up almost 35 percent of all the sources (31) that produce carbon black. The total capital cost is \$32.4 million or \$2.95 million per plant. This is 0.7 percent of the mean expenditure or 1.6 percent of the smallest 1977 capital expenditure of companies within the industry. The industry should have little difficulty raising the capital for such investments, because: (1) the debt/equity ratio of the firms is lower than for most industries (between 19.90 and 41.6); (2) the amount of credits obtained from investments is substantial, and (3) profits are up among many oil companies with which carbon black production is connected.

TABLE 6-8
CAPITAL COST TO THE AVERAGE ALUMINUM FIRM

<u>Alternative 8-Hour CO Standards</u>	<u>Capital Cost Per Firm (\$10³)</u>	<u># of Firms Controlling</u>	<u>% of 1978 Capital Expenditure</u>	<u>% of Long-Term Debt</u>
7 ppm	\$ 22,000	2	2.9	2.1
9 ppm	22,000	2	2.9	2.1
12 ppm	22,000	2	2.9	2.1
15 ppm	22,000	1	2.9	2.1

Table 6-9 compares the average capital cost for firms needing control under each alternative CO NAAQS investigated. The low average capital cost differences result in an insignificant impact on the average firm. The primary effect would be a change in the number of sources subject to control requirements.

6.2.4 Annualized Cost Impacts

6.2.4.1 Industries with Positive Annualized Cost of Control

6.2.4.1.1 Primary Aluminum

Table 6-10 presents the after-tax annualized cost for the NAAQS options for the typical firm within the primary aluminum industry. A price increase of this magnitude may not have a significant effect on the industry for two reasons. First, transportation of aluminum costs approximately \$0.014 per pound per ton-mile (EEA, 1979). Therefore, an increase in transportation distance of an alternative source of aluminum of 150 miles would completely offset the price increase. Second, the aluminum industry is currently experiencing increases in demand. Operating at 90 percent of full capacity (Bureau of Mines, 1978), sources within the industry are in a strong position to fully pass through costs without causing a significant shift in competitive posture.

6.2.4.1.2 Gray Iron

Table 6-11 compares the average after-tax annualized cost for gray iron foundries. As can be seen, none of the options under consideration cause an increase of greater than one percent in product price for a foundry requiring control.

The after-tax annualized cost of the 9 ppm standard is \$18,900 per plant, corresponding to an increase in the average cost of production of \$0.001 to \$0.008 per pound, depending on the size of the foundry. The increase in cost to our benchmark firm (Company 2, Table 6-4) would be \$0.001, reflecting a 0.7 percent increase in price.

TABLE 6-9
CAPITAL COST TO THE AVERAGE CARBON BLACK FIRM

<u>Alternative 8-Hour CO Standards</u>	<u>Capital Cost Per Plant (\$10³)</u>	<u># of Plants Controlling</u>	<u>% of 1978 Capital Expenditure</u>	<u>% of Long-Term Debt</u>
7 ppm	\$ 3,040	12	0.69	0.48
9 ppm	2,950	11	0.67	0.46
12 ppm	3,100	6	0.70	0.49
15 ppm	3,100	4	0.70	0.49

TABLE 6-10
ANNUALIZED COST FOR AN AVERAGE ALUMINUM FIRM

<u>Alternative 8-Hour CO Standards</u>	<u>After-Tax Annualized Cost (\$10³)</u>	<u># of Sources Controlling</u>	<u>% Increase in Price* (@ \$0.62/lb)</u>
7 ppm	\$ 12,680	2	4.7
9 ppm	12,680	2	4.7
12 ppm	12,680	2	4.7
15 ppm	12,680	1	4.7

*Calculated by dividing before-tax annualized cost by annual revenue.

TABLE 6-11
ANNUALIZED COST FOR AN AVERAGE GRAY IRON FIRM

<u>Alternative 8-Hour CO Standards</u>	<u>After-Tax Annualized Cost (\$10³)</u>	<u># of Sources Controlling</u>	<u>% Increase in Price* (@ \$0.62/lb)</u>
7 ppm	\$ 17.700	18	0.78
9 ppm	18.900	12	0.82
12 ppm	15.633	4	0.69
15 ppm	20.700	1	0.91

*Calculated by dividing before-tax annualized cost by annual revenue.

6.2.4.2 Industries with Negative Annualized Cost of Control

6.2.4.2.1 Maleic Anhydride

Two sources in the maleic anhydride industry must control CO to meet a 9 ppm eight-hour NAAQS. The after-tax annualized cost is \$24,000 per plant, which is assumed to be distributed among the stockholders. However, since the mean stockholders' equity for a company producing maleic anhydride is approximately \$3.11 billion, this is only a 0.0008 percent return to the stockholders. The negative annualized cost does indicate that this is an investment which would not change the ability of a company requiring control to operate within the market.

All of the NAAQS options result in either no cost or negative annualized cost to the maleic anhydride industry. The magnitude of these after-tax costs are presented in Table 6-12.

The annualized credit associated with the investment for the 7 ppm standard is \$39,600 per firm, adjusted for taxes. This negative cost is an insignificant additional dividend to stockholders (approximately 0.0012 percent), but a savings to the average firm of \$415,600 per year over the current standard.

6.2.4.2.2 Steelmaking

The 9 ppm eight-hour standards require controls for one steelmaking facility. The after-tax annualized cost was calculated to be \$55,000 per year per plant, representing a \$0.004 payment for each dollar of stockholders' equity.

Table 6-13 compares the negative annualized costs incurred under the various alternatives. It should be noted that the steel industry has the largest fluctuation of average impact of any of the industries affected. The level of control required changes the profitability of the pollution control investment.

TABLE 6-12
AVERAGE AFTER-TAX RETURN FROM CONTROL OF CO FOR AN
AVERAGE MALEIC ANHYDRIDE FIRM

<u>Alternative 8-Hour CO Standards</u>	<u>Annualized Return (\$10³)</u>	<u># of Sources Controlling</u>	<u>¢/\$ Return on Stockholders' Equity</u>
7 ppm	\$ 39.6	3	0.0012
9 ppm	24.0	2	0.0008
12 ppm	180.2	2	0.0058
15 ppm	110.0	1	0.0035

TABLE 6-13
AVERAGE ANNUALIZED RETURN PER FIRM IN THE STEELMAKING INDUSTRY

<u>Alternative 8-Hour CO Standards</u>	<u>Annual Return per plant (\$10³)</u>	<u># of Sources Controlling</u>	<u>¢/\$ Return on Stockholders' Equity</u>
7 ppm	\$ 1100	2	0.080
9 ppm	55	1	0.004
12 ppm	550	1	0.040
15 ppm	-	0	-

6.2.4.2.3 Carbon Black

The after-tax annualized credit under the current 9/1 eight-hour standard is \$655,000 per plant. The savings translates into a \$0.040 return on each dollar of equity. Table 6-14 presents the annualized return for alternative 1 ex ex CO NAAQS options under consideration.

The after-tax annualized savings due to the most stringent standard (7 ppm eight-hour) is \$690,000 per plant. This is only \$0.002 per dollar of equity increase over the 9/1 standard, while the 12 ppm standard yields an after-tax annualized credit for each plant of \$647,000, or a reduction in benefits of \$8,000 per year. Again, this change does not affect any operations of these large corporations.

Since the impact on the operation of the firm is not affected by an increase in dividends of less than one percent, the differential impact of the regulatory options is not significant.

6.3 IMPLICATIONS OF CO NAAQS CONTROL COSTS FOR SMALL BUSINESSES

The preceding material was prepared prior to Congress's enactment of the Regulatory Flexibility Act, requiring that regulatory agencies consider the economic implications of major federal actions affecting small business enterprises. This section briefly discusses both the likelihood and degree of small business impacts.

The probable sources of impacts to small business include two of the four control programs that appear in Table 1 and elsewhere. These are

- Inspection/Maintenance Programs (see Chapter 5); and
- Stationary Source Control Programs.

TABLE 6-14

AVERAGE ANNUALIZED RETURN PER FIRM IN THE CARBON BLACK INDUSTRY

<u>Alternative 8-Hour CO Standards</u>	<u>Annual Return per plant (\$10³)</u>	<u># of Sources Controlling</u>	<u>¢/\$ Return on Stockholders' Equity</u>
7 ppm	\$ 690	12	0.042
9 ppm	655	11	0.040
12 ppm	647	6	0.040
15 ppm	645	4	0.039

Neither the FMVCP nor the TCM programs should result in small business effects. The TCM should not affect small businesses because the costs of the program fall entirely to government. Impacts associated with FMVCP requirements fall to the automobile manufacturers, who must retool to accommodate the performance standards. None of the U.S. automobile manufacturers are classifiable as small businesses by SBA employment size standards (1000 employees for SIC 3711 -- Motor Vehicle and Passenger Car Bodies; 500 employees for SIC 3714 -- Motor Vehicle Parts and Accessories). In 1979, these two industries together employed 807,500 persons, of which over 80 percent are production workers. Considering the number of domestic manufacturers (i.e., GMC, Ford, AMC, Chrysler, several specialty manufacturers, and domestic operations of foreign manufacturers), no small businesses operate in this industry. Therefore, no impacts fall to this class of business enterprise.

Additionally, the analysis assumes that FMVCP costs are passed on to the purchasers of cars, trucks, motorcycles, etc. It is conceivable that the incremental cost of CO control might affect small enterprises that purchase motor vehicles for their businesses. However, because the CO part of the control program adds only about \$180 to the price of a vehicle that may cost over \$12,000, direct impact to the purchaser should be negligible.

The I/M program could affect small businesses in that a decentralized, gas station-operated inspection program would impact gasoline retailers. However, I/M administration costs are borne by local governments and costs are largely recovered through an inspection fee. Moreover, because inspection failures will produce increased demand for repair services, and higher receipts at repair centers, any negative impact is likely to be mitigated, if not overtaken, by increased earnings.

Stationary source CO controls can affect small businesses if the industries that must control are comprised predominantly of small concerns. Tables 4-1

and 4-2 present capital and annualized costs of stationary source CO control, respectively. The tables show that, nationwide, only 29 sources in six industries will impose control under a 9/1 CO standard. Three of these industries, which account for 13 sources, experience negative costs, i.e., control of CO generates savings because of steam credits, resulting in positive economic impacts. The industries showing positive costs and the number of sources controlled in each include: steelmaking (1), primary aluminum (2), municipal incineration (1), and gray iron foundries (12).

Of this group, iron represents the only candidate for small business effects. Gray iron companies are classified as "small" by SBA if they have less than 500 employees. Ownership of gray iron foundries ranges from automobile manufacturing firms to small family owned and operated firms. National total employment in this industry (SIC 3321) is 152,100, and average employment per foundry (although not necessarily per firm) is slightly less than 100 persons, indicating a potential small business impact. The CO NAAQS results in control of only 12 foundries, however, which constitute less than one percent of the total population of gray iron foundries. Those needing control in this hypothetical analysis are the 12 highest CO emitting domestic foundries. They represent hourly throughputs in the range of 25-96 tons of charge, which equals approximately 20-79 tons of gray iron produced. The average facility in the U.S. produces about 5 tons per hour. The facilities modeled for this cost and economic analysis used 20 tons per hour as the average size for larger production facilities and 5 tons per hour as the average size for smaller production facilities. Hence, the sources needing controls to attain a 9/1 NAAQS represent large facilities and are probably not small businesses. Additionally, as shown in Table 6-15, even for smaller firms, CO control costs do not impose a significant operating cost burden, although very small firms might face capital availability constraints. Given the size of controlled facilities, it is unlikely that smaller firms are those controlled by the standard. It is therefore possible to conclude that the stationary source control program does not constitute an economic burden for small business concerns.

TABLE 6-15

CONTROL COSTS AS A PERCENTAGE OF
CAPITAL EXPENDITURES AND VALUE ADDED
BY SIZE OF ESTABLISHMENT FOR GRAY IRON
(SIC 3321)

Establishment Size (# of employees)	Capital Expenditures ^{a/} Per Establishment (\$10 ³)	Capital Cost as a Percentage of Capital Expenditures Per Establishment	Value Added Per Establishment ^{a/} (\$10 ³)	After-Tax Annualized Cost as a Percentage of Value Added Per Establishment
50 to 99	131.7	10.8	1,794.0	0.8
100 to 249	285.2	5.0	4,397.8	0.3
250 to 499	866.3	1.6	11,240.2	0.1
500 to 999	904.5	1.6	20,323.6	0.1
1,000 to 2,499	9,457.0	0.2	52,185.0	b/
2,500 or more	14,952.1	0.1	160,635.9	b/

a/ National average

b/ Less than .1 percent

SOURCE: Bureau of the Census, 1972 Census of Manufactures, Industry Series MC-72(22)33B.
(Adjusted to 1979 using the producer price index for industrial commodities.)

APPENDIX A: FEDERAL MOTOR VEHICLE EMISSION CONTROL
PROGRAM (FMVCP)

The costs of the FMVCP are estimated for the following vehicle categories:

- Light-duty vehicles
- Light-duty trucks
- Heavy-duty vehicles
- Motorcycles

The primary sources of cost estimates for the vehicle emission standards are an analysis of FMVCP costs for hydrocarbon control by the EPA Office of Mobile Sources (Gray, 1983), and the previous regulatory analysis for ozone (EPA, 1979). All costs are updated to 1984 dollars.

The FMVCP controls gaseous emissions from combustion and evaporative emissions from fuel storage. Evaporative emissions consist of hydrocarbons only, and therefore are not included in this discussion. FMVCP costs are presented by initial cost of emission controls, annualized capital charges, maintenance costs, increased costs of unleaded fuel, and costs for control at altitude. In previous analyses, fuel economy improvements in later model year vehicles have been credited to the FMVCP, resulting in substantial credits. These fuel economy improvements are the result of technical changes brought about by Federal Fuel Economy Standards, fuel prices, consumer demand for more efficient vehicles and other factors as well as the FMVCP. Thus it is not possible to isolate what portion the benefits of fuel economy improvements, if any, should be allocated to the FMVCP, and no credit is taken in this analysis.

A.1 LIGHT-DUTY VEHICLES

A.1.1 Initial Cost of Emission Control Systems

Effective standards of control for automobile carbon monoxide emissions began with the 1972 model year; the CO standard, effective through 1974, was 39.0 grams/mile. The standard was achieved using an air pump, which added an initial cost per vehicle of \$41 (EPA, 1979; Automotive News, 1979). The control system also reduced hydrocarbon emissions; the initial cost was apportioned equally between these pollutants, making the cost attributable to CO approximately \$21 per vehicle.

In the 1975-79 model years, an oxidation catalyst (also called a dual catalyst) was used to achieve a standard of 15 grams/mile. The initial cost of the oxidation catalyst is \$240 per vehicle (EPA, 1978a). Of this cost, approximately \$16 was attributable to an exhaust gas recirculation (EGR) system used for NO_x reduction only. Therefore, \$224 per vehicle was spent to reduce CO and hydrocarbons; again, the CO share was half, or \$112 per vehicle.

The 1980 model year required emissions of not more than 7.0 grams/mile; such a reduction was achieved using a three-way catalyst at an initial cost of \$338 per vehicle (EPA, 1978a). Removing the EGR cost (\$16) and allocating a share to hydrocarbons and NO₂, the CO portion was approximately \$124.

The emission standard again was lowered, beginning with the 1981 model year, to 3.4 grams/mile. The typical control technology is a three-way catalyst augmented with an oxidation cleanup catalyst. An EPA study of control technology in place in 1981 through 1983 estimated that the portion of total control system cost attributable to CO control was about \$133 in 1981-1982 and about \$145 for 1983 (Gray, 1983). The cost for 1983 was assumed to be static through the remaining projection years.

Initial capital charges for the FMVCP for CO in 1987, 1990 and 1995 are estimated by multiplying the model year cost per vehicle by the projected or actual new car sales. These products are summed to obtain the cumulative cost. Table A-1 presents these estimates for a FMVCP scenario that keeps the 3.4 gpm equipment beyond model year 1981 automobiles and light duty trucks.

Table A-1 also presents the annualized nationwide capital costs of FMVCP for the projection years. These costs were calculated by multiplying the total capital expenditure for each model year by (1) a capital recovery factor of 16.3 percent (assuming the discount rate for household is 10.0 percent and that cars have an average life of 10 years), and (2) the fraction of each model year fleet in operation at the end of the calendar year.

A.1.2 Maintenance Costs

The use of certain emission control systems leads to different costs and/or savings on typical maintenance relative to uncontrolled vehicles. As shown in Table A-2, cars equipped with oxidation or three-way catalysts are assumed to realize a net annual savings of \$88 in ten years, or \$8.80 per year. The items in Table A-2 indicate expected changes in the needed maintenance between controlled vehicles and 1975 model year vehicles. The costs presented are considered to be a case of minimum savings since the prices assumed for sparkplug and point/condenser changes are probably low. The increase in oil change intervals, which at least in part is due to the use of unleaded fuel, is not considered. Also, O₂ sensors are required only for vehicles with feedback fuel systems, and such vehicles comprised less than 75 percent of gas-fueled LDV's through 1983. Thus the entire cost for O₂ sensor replacement is conservative. The \$65 miscellaneous cost for repair of emission control systems is in addition to any repairs attributable to inspection and maintenance programs.

No maintenance charges are experienced in pre-1975 vehicles. Table A-3 presents the estimated future maintenance savings calculated by multiplying the savings per vehicle by the future year population for each model year

TABLE A-1

ANNUALIZED CAPITAL COST INCREASE FOR LDV'S DUE TO FMVCP CO CONTROLS
(In constant 1984 dollars)

Year	New Car Registrations ^a (10 ⁶)	Initial Cost Increase/Car (\$)	Total Capital Cost (\$10 ⁶)	Fractions of Vehicles Remaining In, ^b 1987 1990 1995	Annualized Capital Charge (\$10 ⁶) 1987 1990 1995
1995	12.1	145	1,754.5		
1994	12.0	145	1,740.0	0.82	234.22
1993	12.0	145	1,740.0	0.96	271.94
1992	11.9	145	1,725.5	0.95	269.11
1991	11.9	145	1,725.5	0.94	264.06
1990	11.8	145	1,711.0	0.92	258.44
1989	11.5	145	1,667.5	0.88	245.12
1988	11.2	145	1,624.0	0.96	228.03
1987	11.0	145	1,595.0	0.95	251.17
1986	10.7	145	1,551.5	0.94	244.09
1985	10.4	145	1,508.0	0.92	242.48
1984	10.1	145	1,464.5	0.95	232.38
1983	8.9	145	1,290.5	0.88	233.23
1982	7.8	133	1,037.4	0.94	224.12
1981	8.4	133	1,117.2	0.77	200.27
1980	8.8	124	1,091.2	0.92	193.29
1979	10.4	112	1,164.8	0.68	161.77
1978	10.9	112	1,220.8	0.57	114.84
1977	10.9	112	1,220.8	0.84	148.62
1976	9.8	112	1,097.6	0.77	152.78
1975	8.3	112	929.6	0.45	136.79
1974	8.7	21	182.7	0.68	128.95
1973	11.4	21	239.4	0.34	113.29
1972	10.5	21	220.5	0.45	89.44
1971	9.8	21	205.8	0.34	60.75
				0.26	39.35
				0.19	18.16
				0.14	2.97
				0.12	5.46
				0.10	4.31
					3.35
			30,825.3		1,994.76 2,293.26 2,639.04

^a - Historical data (1970-1984) from Automotive News, 1984.

^b - From McCurdy, 1984.

Projections from EEA, 1984.

TABLE A-2

MAINTENANCE CHANGES OVER 100,000 MILES
(In constant 1984 dollars)

<u>Maintenance</u>	<u>Total Cost of Maintenance</u>	<u>Cost Related to CO Control</u>
Change O ₂ sensor twice	2 x \$55 = \$110	1/3 x 110 = \$37
Miscellaneous emissions system repairs	\$65	1/3 x 65 = \$22
Save five plug changes	5 x \$13 = \$(-65)	1/2 x (-65) = \$(-32)
Save 10 point/condenser changes	10 x \$13 = \$(-130)	1/2 x (-130) = \$(-65)
Save one muffler change	<u>\$(-150)</u>	<u>1/3 x (-150) = \$(-50)</u>
TOTAL		\$ (-88) per 10 yrs

SOURCE: Gray, 1983.

TABLE A-3
ANNUAL OPERATING AND MAINTENANCE SAVINGS FOR LDV's
DUE TO FMVCP CO CONTROLS

(In constant 1984 dollars)

Year	Annual O & M Savings (\$)	Vehicle Population (\$10 ⁶)			Total Annual Savings (\$10 ⁶)		
		1987	1990	1995	1987	1990	1995
1995	8.8			9.92			
1994	8.8			11.52			87.30
1993	8.8			11.40			101.38
1992	8.8			11.19			100.32
1991	8.8			10.95			98.47
1990	8.8		9.68	10.38			96.36
1989	8.8		11.04	9.66		85.18	91.34
1988	8.8		10.64	8.62		97.15	85.01
1987	8.8	9.02	10.34	7.48	79.38	93.63	75.86
1986	8.8	10.27	9.84	6.10	90.38	90.99	65.82
1985	8.8	9.88	9.15	4.68	86.94	86.59	53.68
1984	8.8	9.49	8.48	3.43	83.51	80.52	41.18
1983	8.8	8.19	6.85	2.31	72.07	74.62	30.18
1982	8.8	6.86	5.30	1.48	60.37	60.28	20.33
1981	8.8	7.06	4.79	1.18	62.13	46.64	13.02
1980	8.8	6.78	3.96	1.06	59.66	42.15	10.38
1979	8.8	7.07	3.54	1.04	62.22	34.85	9.33
1978	8.8	6.21	2.83		54.65	31.15	9.15
1977	8.8	4.91	2.07		43.21	24.90	
1976	8.8	3.33	1.37		29.30	18.22	
1975	8.8	2.16	1.00		19.01	12.06	
1974	0.0	1.65	0.87		0.00	8.80	
1973	0.0	1.60			0.00	0.00	
1972	0.0	1.26			0.00		
1971	0.0	0.98			0.00		
		96.72	101.75	112.40	802.82	887.74	989.12

(i.e., new car sales for each model year times the proportion of remaining vehicles).

A.1.3 Use of Unleaded Fuel

Catalyst control systems require the use of unleaded fuel, which is more expensive than regular gasoline. This difference is partially due to a slightly higher refining cost of unleaded fuel and partially because of pricing strategies of gasoline retailers. If the cost differential between regular and unleaded gasolines is heavily influenced by production volume, leaded gasoline may become more expensive than unleaded in the future due to projected reduction in demand for leaded gasoline. However, in the interest of keeping the calculations in this document conservative, a constant future differential of \$0.05 per gallon was assumed. (Gray, 1983)

Table A-4 presents estimates of the increased cost of unleaded fuel for LDVs that can be allocated to the FMVCP for CO. Available estimates of future total LDV unleaded fuel use and the \$0.05 per gallon differential allow estimation of total added cost of unleaded fuel use for LDV. Added fuel costs must be divided between HC and CO control for pre-1981 vehicles, and between HC, CO and NO_x for 1981 and later. The fractions due to the CO FMVCP cited in Table A-4 are based on available EPA estimates of this distribution.

A.1.4 Emission Control at Altitude

The high altitude requirements prior to 1984 will not be addressed here, since they resulted in a cost of consumer of much less than \$1 per car (U.S. EPA, 1983). Almost every 1984 and later model year LDV must be equipped with self-actuating emission control hardware to achieve standards at both low and high altitude. This program is expected to add between \$13 and \$16 to the purchase price of the average vehicle (FR, 1983). The analysis in Table A-5, based on \$16 per vehicle, provides a conservative estimate of the annualized cost of this additional hardware.

TABLE A-4.

COSTS OF UNLEADED FUEL USE DUE TO FMVCP FOR LDT
(In constant 1984 dollars)

Year	LDT Unleaded Fuel Use (10 ⁹ gallons) ^a	Unleaded Fuel Price Differential (\$/gallons) ^b	Total Added Cost of HDV Unleaded Fuel for LDT (\$10 ⁹)	Fraction due to CO FMVCP ^b	CO Portion of Added Unleaded Fuel Cost (\$10 ⁹)
1987	49.9	\$ 0.05	2.50	0.43	1.03
1990	50.2	\$ 0.05	2.51	0.40	1.00
1995	51.1	\$ 0.05	2.56	0.36	0.92

^aEEA, 1984

^bGray, 1983

TABLE A-5

ANNUALIZED CAPITAL COST INCREASE FOR LDV'S DUE TO FMVCP CO CONTROLS AT ALTITUDE
(In constant 1984 dollars)

Year	New Car Registrations (10 ⁶)	Initial Cost Increase/Car (\$)	Total Capital Cost (\$10 ⁶)	Fraction of Vehicles Remaining In: 1987 1990 1995	Annualized Capital Charge (\$10 ⁶) 1987 1990 1995
1995	12.1	16	193.6		
1994	12.0	16	192.0	0.82	25.84
1993	12.0	16	192.0	0.96	30.01
1992	11.9	16	190.4	0.95	29.69
1991	11.9	16	190.4	0.94	29.14
1990	11.8	16	190.4	0.92	28.52
1989	11.5	16	188.8	0.82	25.20
1988	11.2	16	184.0	0.96	28.76
1987	11.0	16	179.2	0.95	27.72
1986	10.7	16	176.0	0.82	23.50
1985	10.4	16	171.2	0.96	26.76
1984	10.1	16	166.4	0.95	25.74
			161.6	0.94	24.73
			2,185.6		100.72 180.19 274.38

A.2 LIGHT-DUTY TRUCKS

A.2.1 Initial and Annualized Cost of Emission Control Systems

Table A-6 presents estimated initial and annualized capital costs for FMVCP controls for light-duty trucks (LDT). The initial individual vehicle costs of emission control systems for (LDT) were assumed to be the same as for automobiles from 1972 to 1980. The standard schedule is slightly different from that for LDV's in the 1972-82 period, however, since the most stringent standards are implemented in 1983 instead of 1981 and the interim 7.0 gpm FMVCP standard applies for four years while it is only one year for LDV's. The FMVCP applied only to trucks of 6,000 pounds or less until 1979, when coverage was extended include trucks up to 8,500 pounds. This change is reflected in the truck populations in Table A-6.

A.2.2 Maintenance Costs

For LDT operating for 12 years, it has been estimated that the FMVCP will reduce the number of spark plug replacements from eight to four at a savings of \$30, and reduce exhaust system replacements from two to one, saving \$167. Allocating half of the spark plug saving and a third of the exhaust system savings to CO, the average annual maintenance savings per LDT is about \$5.90. Table A-7 applies this savings to projected LDT fleets in 1987, 1990 and 1995.

A.2.3 Use of Unleaded Fuel

Table A-8 presents estimates of the increased costs of unleaded fuel for LDT's that can be allocated to the FMVCP for CO, using the methodology described for LDV in A.1.4, above. Since only a small fraction of recent LDT's use three-way catalyst systems, it is assumed that half of the total added cost of unleaded fuel for LDT should be allocated to CO.

TABLE A-6

ANNUALIZED CAPITAL COST INCREASE FOR LDT'S
DUE TO FMVCP CO CONTROLS

(In constant 1984 dollars)

Year	New LDT Sales ^a (10 ⁶)	Initial Cost Increase/Car-b(\$)	Total Capital Cost (\$10 ⁶)	Fraction of Trucks Remaining Inc ^c		Annualized Capital Charge (\$10 ⁶)	
				1987	1990	1987	1990
1995	4.68	180	842.40				115.20
1994	4.57	180	822.60		0.84		129.90
1993	4.45	180	801.00		0.97		121.27
1992	4.34	180	781.20		0.93		111.92
1991	4.22	180	759.60		0.88		102.64
1990	4.11	180	739.80		0.83		93.94
1989	3.99	180	718.20		0.84	101.17	85.35
1988	3.88	180	698.40		0.97	113.42	77.32
1987	3.76	180	676.80		0.93	105.74	69.42
1986	3.65	180	657.00	0.84	0.88	92.55	63.11
1985	3.53	180	635.40	0.97	0.83	103.75	56.89
1984	2.98	180	536.40	0.93	0.78	96.20	44.54
1983	2.43	120	291.60	0.88	0.73	76.85	22.31
1982	1.99	116	230.84	0.83	0.68	39.40	16.16
1981	1.70	117	198.90	0.78	0.63	29.31	12.95
1980	1.99	112	222.88	0.71	0.59	23.64	13.06
1979	2.79	112	312.48	0.68	0.55	24.67	16.28
1978	1.14	112	127.68	0.63	0.51	32.05	5.82
1977	1.19	112	133.28	0.59	0.47	17.26	
1976	1.47	112	164.64	0.55	0.43	11.93	
1975	1.21	112	135.52	0.51	0.40	13.67	
1974	1.62	21	34.02	0.47	0.36	10.37	
1973	1.85	21	38.85	0.43	0.32	2.38	
				0.40	0.28	2.53	
			10,559.49			571.58	812.77
							1,158.08

a - Historical data (1973-1980) from EEA, 1982. Projections (1981-1995) based on EEA, 1984.
Figures before 1979 do not include trucks over 6,000 ps, which were not subject to FMVCP.

b - Cost from 1973-1980 assumed the same as LHV; land later cost from Gray, 1983.

c - EEA, 1980. First year adjustment based on Wards Communications, 1982.

TABLE A-7

ANNUAL OPERATING AND MAINTENANCE SAVINGS FOR LDT'S
DUE TO FMVCP CO CONTROLS

(In constant 1984 dollars)

Year	Annual O&M Savings (\$)	Vehicle Population (10 ⁶)			Total Annual Savings (\$10 ⁶)		
		1987	1990	1995	1987	1990	1995
1995	5.90			3.93			23.19
1994	5.90			4.43			26.14
1993	5.90			4.14			24.43
1992	5.90			3.82			22.54
1991	5.90			3.50			20.65
1990	5.90		3.45	3.21		20.36	18.94
1989	5.90		3.87	2.91		22.83	17.17
1988	5.90		3.61	2.64		21.30	15.58
1987	5.90	3.16	3.31	2.37	18.64	19.53	13.98
1986	5.90	3.54	3.03	2.15	20.89	17.88	12.69
1985	5.90	3.28	2.75	1.94	19.35	16.23	11.45
1984	5.90	2.62	2.18	1.52	15.46	12.86	8.97
1983	5.90	2.02	1.65	1.14	11.92	9.74	6.73
1982	5.90	1.55	1.25	0.86	9.15	7.38	5.07
1981	5.90	1.24	1.00	0.68	7.32	5.90	4.01
1980	5.90	1.35	1.09	0.72	7.97	6.43	4.25
1979	5.90	1.76	1.42	0.89	10.38	8.38	5.25
1978	5.90	0.67	0.54	0.32	3.95	3.19	1.89
1977	5.90	0.65	0.51		3.84	3.01	
1976	5.90	0.75	0.59		4.43	3.48	
1975	5.90	0.57	0.44		3.36	2.60	
1974	0.00	0.70	0.52		0.00	0.00	
1973	0.00	0.74	0.52		0.00	0.00	
		24.6	31.73	41.17	136.64	181.07	242.90

TABLE A-8.

COSTS OF UNLEADED FUEL USE DUE TO FMVCP FOR LDT
(In constant 1984 dollars)

Year	LDT Unleaded Fuel Use (10 ⁹ gallons) ^a	Unleaded Fuel Price Differential (\$/gallons) ^b	Total Added Cost of HDV Unleaded Fuel for (\$10 ⁹)	Fraction due to CO FMVCP ^b	CO Portion of Added Unleaded Fuel Cost (\$10 ⁹)
1987	13.5	0.05	0.68	0.50	0.34
1990	15.8	0.05	0.70	0.50	0.40
1995	18.9	0.05	0.95	0.50	0.48

^aEEA^bGray, 1983

A.2.4 Emission Control at Altitude

Average capital cost for additional gasoline-fueled LDT emission controls for high altitude is about \$20, and annual production of such trucks is about 80,000 (Gray, 1983). This is divided equally between CO, HC, and NO_x, with the results shown in Table A-9.

A.3 HEAVY-DUTY VEHICLES

A.3.1 Initial Cost of Emission Control Systems

The cost to the consumer, beginning with the 1985 model year, of the HC and CO emission standards for Heavy-Duty Diesel Engines (HDDE) is estimated to be \$230 for each engine. Assuming annual sales of 300,000 engines, the cost attributable to CO control is 69 million dollars annually. (Gray, 1983)

For Heavy-Duty Gasoline Engines (HDGE), the cost to the consumer of the HC and CO emission standards for the 1985 and 1986 model years will average about \$125 per engine, in addition to the estimated \$185 cost of meeting the 1979 model year standards for controlling HC, CO, and NO_x. Assuming an annual production of 340,000 HDGEs, the annual cost attributable to CO control is about \$21 million through 1984, and about \$42 million in 1985 and 1986. (Gray, 1983)

The HC and CO emission standards for the 1987 and later model years for HDGE with a gross vehicle weight (GVW) between 8,500 and 14,000 pounds will become more stringent, requiring catalysts on most of those trucks. This is expected to result in an increase (above the 1986 model year) of \$155 per truck. Sales of HDGE with GVW between 8,500 and 14,000 pounds are expected to average about 264,000 units annually and sales of those with GVW over 14,000 pounds is expected to average about 96,000 units annually. Based on these estimates, the total cost for model years 1987 and later is anticipated to be about \$67 million annually (Gray, 1983). Combining this with the above costs for previously-required controls, total annual costs of CO control for HDDE and

TABLE A-9

ANNUALIZED CAPITAL COST INCREASE FOR LDT'S DUE TO
FMVCP CONTROLS AT HIGH ALTITUDE

(In constant 1984 dollars)

Year	New Trucks at Altitude ^a (10 ⁶)	Initial Cost Increase/Truck ^a ($\$$)	Total Capital Cost ($\$10^6$)	Fraction of Trucks Remaining In ^b		Annualized Capital Charge ($\$10^6$)	
				1987	1990	1987	1990
1995	0.08	6.7	0.54				
1994	0.08	6.7	0.54		0.84		0.07
1993	0.08	6.7	0.54		0.97		0.08
1992	0.08	6.7	0.54		0.93		0.07
1991	0.08	6.7	0.54		0.88		0.07
1990	0.08	6.7	0.54		0.83		0.07
1989	0.08	6.7	0.54	0.84	0.78	0.07	0.06
1988	0.08	6.7	0.54	0.97	0.73	0.08	0.06
1987	0.08	6.7	0.54	0.93	0.68	0.07	0.05
1986	0.08	6.7	0.54	0.84	0.63	0.07	0.05
1985	0.08	6.7	0.54	0.97	0.59	0.08	0.05
1984	0.08	6.7	0.54	0.93	0.55	0.07	0.04
				0.88	0.51	0.07	0.04
			6.43	3.62	5.96	0.29	0.48
							0.71

a - Gray, 1983.

b - EEA, 1980. First year adjustment based on Wards Communications, 1982.

HDGE are estimated at \$21 million through 1984, \$111 million in 1985 and 1986, and \$136 million in 1987 and thereafter.

A.3.2 Maintenance Costs

No changes in maintenance costs are expected for HDDES. For HDGEs for model years 1985 and 1986, a small increase in annual maintenance costs (\$3.90) is due to minor servicing (operational checks and lubrication) of heated air intake and automatic chokes. The cost attributable to CO control is 0.6 million dollars annually. For the 1987 and later model years, the catalyst-equipped HDGE will realize an annual savings (relative to 1986) of \$49 per truck due to improved spark plug and exhaust system longevity resulting from the use of unleaded gasoline. The related savings attributable to HC control for the 1987 and later model years is \$6.3 million dollars.

A.3.3 Use of Unleaded Fuel

Table A-10 presents estimated HDV unleaded fuel use for 1987, 1990 and 1995, and the derivation of the portion of added unleaded fuel costs due to the FMVCP for CO.

A.4 MOTORCYCLES

Based on an estimated average price increase of \$102 due to FMVCP-required motorcycle controls for CO and HC, and an assumed annual production of 725,000 units, the annual cost for motorcycle controls attributable to the CO FMVCP is about \$37 million. While some FMVCP-required design changes may result in reduced maintenance, data which would allow quantitative estimates of the potential savings are not available. (Gray, 1983)

It has been estimated that leaner air/fuel mixtures required to meet motorcycle FMVCP limits will improve fuel economy by about 20 percent. Based on an estimated motorcycle fuel consumption of 360 million gallons in 1981 and a gasoline price of \$1.20, the annual fuel savings could amount to \$54 million. (Gray, 1983; EIA, 1984)

TABLE A-10.

COSTS OF UNLEADED FUEL USE DUE TO FMVCP FOR HDV
(In constant 1984 dollars)

Year	Unleaded Fuel Use (10 ⁹ gallons) ^a	Unleaded Fuel Price Differential (\$/gallons) ^b	Total Added Cost of HDV Unleaded Fuel for (\$10 ⁹)	Fraction due to CO FMVCP ^b	CO Portion of Added Unleaded Fuel Cost (\$10 ⁹)
1987	0.95	0.05	0.048	0.5	0.024
1990	2.47	0.05	0.124	0.5	0.062
1995	4.06	0.05	0.203	0.5	0.102

^aEEA^bGray, 1983

A.5 AIRCRAFT

EPA has withdrawn aircraft emission standards for CO.

A.6 SUMMARY OF FMVCP COSTS

Annualized costs of the FMVCP for CO as estimated in this Appendix are summarized in Table A-11.

TABLE A-11

TOTAL ANNUALIZED COSTS OF THE FMVCP FOR CO (\$10⁶)

(In constant 1984 dollars)

	1987 ----	1990 ----	1995 ----
Passenger Cars (LDV)			
Hardware	1,994.8	2,293.3	2,639.0
Unleaded Gasoline	1,030.0	1,000.0	920.0
Operating and Maintenance	-802.8	-887.7	-989.1
Altitude Controls	100.7	180.2	274.4
	-----	-----	-----
Total (LDV)	2,322.7	2,585.8	2,844.3
Light-Duty Trucks (LDT)			
Hardware	571.6	812.8	1,158.1
Unleaded Gasoline	340.0	400.0	480.0
Operating and Maintenance	-136.6	-181.1	-242.9
Altitude Controls	0.3	0.5	0.7
	-----	-----	-----
Total (LDT)	775.3	1,032.2	1,395.9
Heavy-Duty Vehicles (HDV)			
Hardware	111.0	111.0	111.0
Unleaded Gasoline	24.0	62.0	102.0
Operating and Maintenance	-6.3	-6.3	-6.3
	-----	-----	-----
Total (HDV)	128.7	166.7	206.7
Motorcycles			
Operating and Maintenance	-17.0	-17.0	-17.0
	-----	-----	-----
Grand Total	3,209.7	3,767.7	4,429.9

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APPENDIX B

STATIONARY SOURCES: METHODOLOGY AND ASSUMPTIONS

B.1 INDUSTRY COVERAGE

B.1.1 Selection Criteria

The industries included for evaluation were selected from a preliminary list of potentially significant CO sources (PEDCo, 1979b). Average process and stack parameters were gathered from recent EPA regulatory and engineering studies for approximately 25 industrial processes. Table B-1 lists those source categories identified. The resulting data (PEDCo, 1979b) indicated, for each process, two production sizes typical of the range of operation and the uncontrolled emission rate, stack height and exhaust gas velocity, temperature, and volume appropriate to each size. Probable control equipment and efficiencies also were identified.

In order to focus the derivation of process-specific control costs on those processes likely to experience some need for emission reduction under any of the alternative standards, it was decided to screen the source list by evaluating the air quality impact of each "model" source.

B.1.2 Air Quality Modeling of "Model Sources"

A single source dispersion model, PTMAX, was used to calculate a predicted maximum concentration for each source (and size of source). PTMAX is an interactive program which calculates the maximum short-term (one-hour) ambient concentration from any point as a function of exhaust and stack characteristics, wind speed, and stability. The program is part of the User's Network for Applied Modeling of Air Pollution (UNAMAP) maintained

TABLE B-1
POTENTIALLY SIGNIFICANT PROCESS SOURCES OF CO

- Petroleum refineries
- Carbon black
 - furnace/oil
 - furnace/gas
- Kraft pulp and paper
- Iron foundries
- Steelmaking
 - sintering
 - basic oxygen furnace (BOF)
- Primary aluminum
- Gas pipelines
- Electric utilities
- Acrylonitrile
- Maleic anhydride
- Industrial combustion
- Charcoal
- Formaldehyde
- Dimethylterephthalate
- Phthalic anhydride
- Coke production
- Cyclohexanol
- Gas-fired process heaters
- Ethylene dichloride
- Reciprocating internal combustion engines

by the Division of Meteorology, EPA. To determine their maximum impact, sources were modeled using their uncontrolled emission rate; no background level was assumed.

PTMAX predicts one-hour levels only. Because the ambient standards consider both one- and eight-hour averaging periods, a method for converting the predicted one-hour into expected eight-hour concentrations was necessary. Persistence factors of 0.5 and 0.7, which represent ratios of eight-hour to one-hour concentrations exhibited by monitored data, were used (Schewe, 1979). The 0.7 factor represents a ratio of maxima and, therefore, produces a worst case estimate. The results of the PTMAX air quality modeling are presented in Table B-2.

Eight of the model processes experienced potentially significant air quality impacts. For the screen, "significant" was defined as 50 percent or more of the most stringent ambient standard to be considered. These processes were:

- Basic oxygen furnace
- Aluminum anode prebake
- Aluminum prebake cells
- Maleic anhydride
- Cyclohexanol
- Formaldehyde
- Ethylene dichloride
- Coke oven charging.

B.1.3 NEDS Screen

The PTMAX modeling indicated potential impacts for source categories with a specific set of process and stack characteristics. The probability that actual sources may deviate from those "model" parameter sets created the need to screen further process categories which might cause ambient violations.

TABLE B-2
PTMAX MODELING RESULTS

Industry	Process Source	Size	8-hour Bounds		
			Lower (ppm)	Upper (ppm)	Distance (km)
Petroleum refining	Catalytic cracking	25,000 BPD	1.49	2.09	0.80
		90,000 BPD	1.58	2.21	1.56
Carbon black	Furnace process	176,000 TPY	1.77	2.48	17.50
		44,000 TPY	2.54	3.55	0.62
Kraft pulp	Recovery boiler	1,500 TPD	0.003	0.004	2.07
		1,000 TPD	0.002	0.003	1.82
Kraft pulp	Kiln	1,500 TPD	0.19	0.26	0.51
		1,000 TPD	0.17	0.23	0.40
Gray iron	Cupola	25 TPH	1.71	2.40	0.37
		1 TPH	0.79	1.09	0.21
Iron and steel	Sinter plant	3.65 MTPY	1.00	1.40	1.13
		1.19 MTPY	0.91	1.27	0.58
Steelmaking	Electric arc	0.10 MTPY	0.02	0.03	0.63
		1.13 MTPY	0.03	0.04	1.58
Steelmaking	BOF	1.61 MTPY	29.92	41.89	0.62
		3.78 MTPY	62.20	87.02	0.60
Primary aluminum	Prebake cells	225,000 TPY	0.87	1.21	1.01
		140,000 TPY	1.12	1.56	0.36
Primary aluminum	Anode prebake	225,000 TPY	7.32	10.24	0.36
		140,000 TPY	6.64	9.30	0.38
Primary aluminum	HSS cell	225,000 TPY	0.45	0.63	1.44
		140,000 TPY	0.55	0.77	0.99
Gas pipeline	Engine exhaust	1,500 HP	0.004	0.005	0.22
Electric utility*	Coal	1,000 MWe	0.001	0.001	2.50
		100 MWe	0.000	0.001	1.15
Electric utility*	Residual oil	1,000 MWe	0.001	0.001	2.24
		100 MWe	0.000	0.001	1.15
Electric utility*	Gas	1,000 MWe	0.001	0.001	2.29
		100 MWe	0.000	0.000	41.93

* 75 m. stack height.

TABLE B-2 (cont'd)
PTMAX MODELING RESULTS

Industry	Process Source	Size	8-hour Bounds		
			Lower (ppm)	Upper (ppm)	Distance (km)
Acrylonitrile	Absorber vent	0.154 MTPY	0.60	0.83	0.61
		0.121 MTPY	0.57	0.80	0.61
Maleic anhydride	Condenser	0.027 MTPY	5.65	7.90	0.31
		0.006 MTPY	4.33	6.06	0.29
Industrial boilers	Coal	50 10 ⁶ Btuh	0.001	0.002	0.41
		250 10 ⁶ Btuh	0.001	0.002	0.58
Industrial boilers	Distillate	1 10 ⁶ Btuh	0.000	0.000	0.21
		10 10 ⁶ Btuh	0.001	0.002	0.25
Industrial boilers	Gas	1 10 ⁶ Btuh	0.000	0.000	0.21
		10 10 ⁶ Btuh	0.001	0.001	0.25
Charcoal	Kiln	215 Lbh	0.10	0.15	0.17
Charcoal	Continuous furnace	7.5 TPH	0.04	0.06	1.06
	wood-drying	7.5 TPH	1.21	1.70	0.40
Formaldehyde	Absorber vent	0.100 MTPY	1.48	2.08	0.18
		0.040 MTPY	2.67	3.73	0.20
Dimethylterephthalate	Scrubber	0.120 MTPY	0.52	0.73	0.44
		0.030 MTPY	0.44	0.62	0.27
Phthalic anhydride	Condensers	0.065 MTPY	0.63	0.88	0.48
		0.047 MTPY	0.56	0.78	0.44
Iron and steel	Coke oven charging	0.35 MTPY	0.82	1.14	0.24
		0.72 MTPY	1.24	1.73	0.22
Cyclohexanol	Product recovery vent	0.110 MTPY	7.13	9.98	0.27
		0.025 MTPY	3.99	5.58	0.17
Process heater	Gas-fired	150 10 ⁶ Btuh	0.000	0.000	0.62
		50 10 ⁶ Btuh	0.000	0.000	0.41
Ethylene dichloride	Fractionation vent	0.440 MTPY	3.31	4.63	0.37
Internal combustion	Diesel	1,200 HP	0.03	0.04	0.20
	Dual fuel	4,300 HP	0.08	0.12	0.31
	Natural gas	1,500 HP	0.004	0.01	0.22
		4,400 HP	0.01	0.01	0.48

To conduct a second screen, the PTMAX program was modified to calculate each source's effective plume rise (a measure of the dispersion characteristics of emissions) and to determine, for that plume rise, the CO emission rate that would yield a carbon monoxide ambient concentration of 0.5 ppm (under worst case meteorological conditions, i.e., wind speed of 2.0 m/s and stability class A). The modified PTMAX program was applied to the source data in the National Emission Data System (NEDS) point source subfile. Therefore, based on actual rather than "model" stack and emission characteristics, this PTMAX screen produced a subfile comprised of those point sources in NEDS which would produce ambient concentrations above 0.5 ppm; the 0.5 ppm concentration was selected as a conservative threshold of potential to cause ambient violations even under the most stringent alternative.

The resulting subfile included over 700 point sources. Additional source categories beyond those eight previously listed then were identified for control cost development based on 1) their expected magnitude of air quality impact, or 2) the number of sources within that category contained in the subfile.

Data validity checks were performed on a number of sources in the subfile. Emission rates (AP-42 uncontrolled vs. NEDS) and their consistency with operating and stack data were verified. After correction for apparent data errors, six additional process categories were identified for cost development; they were:

- Carbon black
- Iron sintering
- Electric arc furnace
- Gray iron cupola
- Conical wood incinerator
- Municipal incinerator.

B.1.4 Source Category Control Cost Development

For the 14 potentially significant processes screened in the preceding two steps, capital and annualized costs were obtained for two typical operating rates within each process category.* The technology selection was based on currently demonstrated control equipment; no experimental technology was considered (PEDCo, 1979a).

As indicated, costs (capital and annualized) were developed for two process sizes which are deemed reflective of the range of typical operation. The two cost estimates were used to construct an exponential equation for each process category which, upon inputting a source's specific annual capacity or production level, would produce the costs of a unit of appropriate size. The log-log curve represented by the equation is used to capture economies or diseconomies of scale inherent in the two size-specific point estimates.

In three cases, a single process size was indicated, hence the control costs for that size were assumed to be linear per unit of production (a uniform \$/ton of product). For one process, the conical wood incinerator, the costs of control do not vary by size; therefore, the capital and annualized costs are level.

B.2 TOTAL COST METHODOLOGY

B.2.1 Evaluation of Ambient Impact

In order to determine the costs incurred by each alternative standard, the evaluation of the extent to which existing sources violate mandated concentration levels constitutes the first step. PTMAX was applied to the 700 point sources in the NEDS subfile. For the purposes of costing,

* There are several exceptions where only one size was costed. See PEDCo, 1979b.

the meteorological assumptions were stability class B and a wind speed of 2.5 m/sec, as it was felt that these represent more realistic atmospheric conditions and would produce consistently valid results from PTMAX (i.e., plume rises of less than 500 m).*

A background level of 2 ppm CO was included to reflect the probable concentration of area sources at points of maximum point source impacts. The 2 ppm background was assumed sufficient since point sources generally are removed from highways and other major transportation routes where high CO concentrations from area sources occur. No natural background was considered.

The background level, assumed equal for all point sources, can be considered either to increase the point's impacts on air quality (since the source's concentration is no longer considered truly in isolation) or to reduce effectively, by 2 ppm, each alternative ambient standard. For ease of analysis, the background was incorporated in the latter manner.

Each point source's maximum concentration was calculated using PTMAX and revised atmospheric conditions. The concentrations of multiple points at any facility were aggregated to the plant level, thereby assuming that the plant impact equals the sum of the process maximum impacts. This procedure will overestimate the actual plant impact because it assumes that these maxima occur at the same location. No interaction among plants was assumed; the source file produced under the revised meteorological assumptions contained 275 sources which did not exhibit a significant degree of co-location. It was believed that the level of source interaction would not be of a magnitude that would jeopardize the conclusions reached using PTMAX.

* PTMAX will calculate ambient concentrations for plume rises above 500 m, but will identify the prediction as invalid.

The calculated plant concentration level then was compared to each alternative CO standard adjusted for background. (The plant total was corrected by the 0.7 persistence factor for comparison with eight-hour standards.) It should be noted that the form of the standard, whether 1 or 5 expected exceedances, was not considered. The calculated impact was used directly. The adjustment to a single or multiple exceedances form of a standard would require varying meteorological conditions to produce the variability exhibited by monitored data. Such a data manipulation was beyond the scope of this analysis. The result is, as with the sum of process maxima, a bias upward in the forecasted impacts.

B.2.2 Calculation of Required Emission Reductions

Emission reductions required under each alternative standard were calculated assuming proportionality between reduction in emissions and air quality levels; a linear rollback equation was used:

$$\% \text{ Emission Reduction} = \frac{\text{Plant Concentration} - (\text{Ambient Standard} - \text{Background})}{\text{Plant Concentration}}$$

If the plant impact does not violate any standard, the equation produces a negative result and no reductions are calculated.

B.2.3 Least-Cost Strategy Determination

The required reduction in emissions refers to plant totals. Since many plants constitute the combined impact of multiple emission points, emission reductions can be produced by a variety of control option combinations. For this analysis, the required emission reductions were obtained through an option or combination of options which resulted in the lowest total annualized cost for the plant, thus accounting for initial capital outlays.

Each plant's control options were calculated and ranked by cost effectiveness, that is, lowest to highest cost per ton of CO removed. All options needed to produce the tonnage emission reduction are applied to each

source in order of decreasing cost effectiveness; that is, the lowest \$/ton removed controls and sources are selected first.

Because of the discrete nature of control technology, it is possible that a plant might employ a less cost-effective means of control simply by choosing control options which have the lowest average annualized cost per unit of reduction. For example, a facility consists of two points: point A emits 100 tons per year and point B emits 200 tons per year. Assume that the required emission reduction is 50 percent for the plant, or 150 tons; point A can be controlled at 90 percent efficiency for \$1/ton; point B may be controlled at 75 percent efficiency for \$2/ton. By a cost-effective ranking, the choice would be to control point A first; however, since point A only provides 90 tons of reduction, point B also must be controlled. As a result, the plant expends \$390 in annualized cost for 240 tons of reduction. However, if only point B were controlled, it could achieve the entire 150 ton reduction at a total annualized cost of \$300. A verification procedure was used, therefore, to ensure lowest total annual cost, in this example, to check whether the controls on point A were necessary;* since they were not, the least-cost algorithm would control point B only. The results of the costing procedure are presented in Section 3.5.

B.3 BENEFITS FROM STEAM CREDITS

The burning of carbon monoxide is an exothermic reaction. If the exhaust stream of CO from a process is sufficiently dense, the energy released from burning the gas may be used in one of two manners. The energy from combusted CO can be used to heat the continuing stream of process gas

* The need for controls on point B are not reverified, however, since point B's controls obviously were necessary to achieve the total reduction.

before combustion. This procedure, called primary heat recovery and illustrated in Figure B-1, can reduce the amount of supplemental fuel needed to burn the process gas. Secondary heat recovery, as illustrated in Figure B-2, generates steam from the heat released from the combusted CO. This steam may be used in certain processes within the plants thereby reducing costs of burning fossil fuels to produce needed steam.

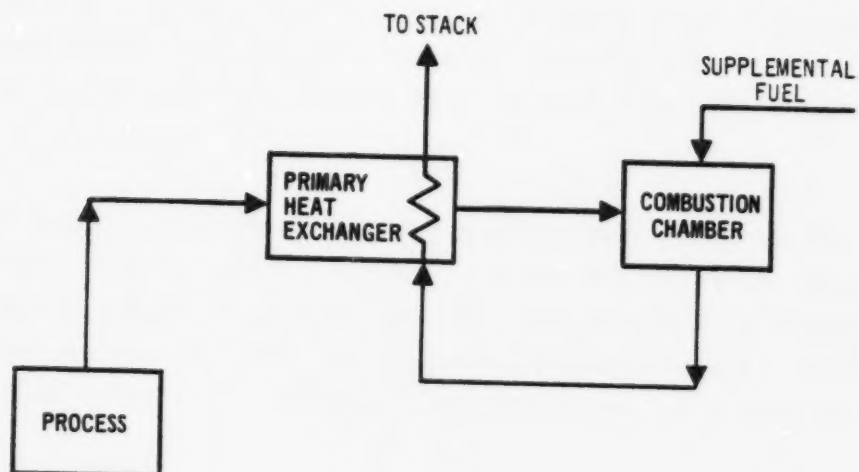
The use of secondary heat recovery increases capital cost, however. For example, using incineration with primary heat recovery to control CO from an iron ore sinter plant producing 1.19×10^6 tons per year incurs a capital cost of \$3.4 million. With the addition of secondary heat recovery the capital cost becomes \$3.86 million, an increase of over 13 percent.

However, the secondary heat recovery provides enough annual steam credit* to more than offset the capital cost increase; using the same sinter plant, control with primary heat recovery operates at an annual cost of \$3.5 million. The addition of secondary heat recovery provides enough steam to provide a net annual savings of \$3.3 million (PEDCo, 1979b).

It should be noted that not all sources can use secondary heat recovery. Its application will depend on the quantity/concentration of CO in the off-stream and the degree of steam-heating requirement (i.e., if supplemental fuel for combustion is necessary). Moreover, it is possible that certain processes would not be amenable to secondary heat recovery because no steam is required. In this event, credits for steam are not valuable since steam normally is not purchased or produced. As a result, firms, in choosing to minimize expenditures, likely would select primary recovery since, without credits, secondary recovery is more expensive.

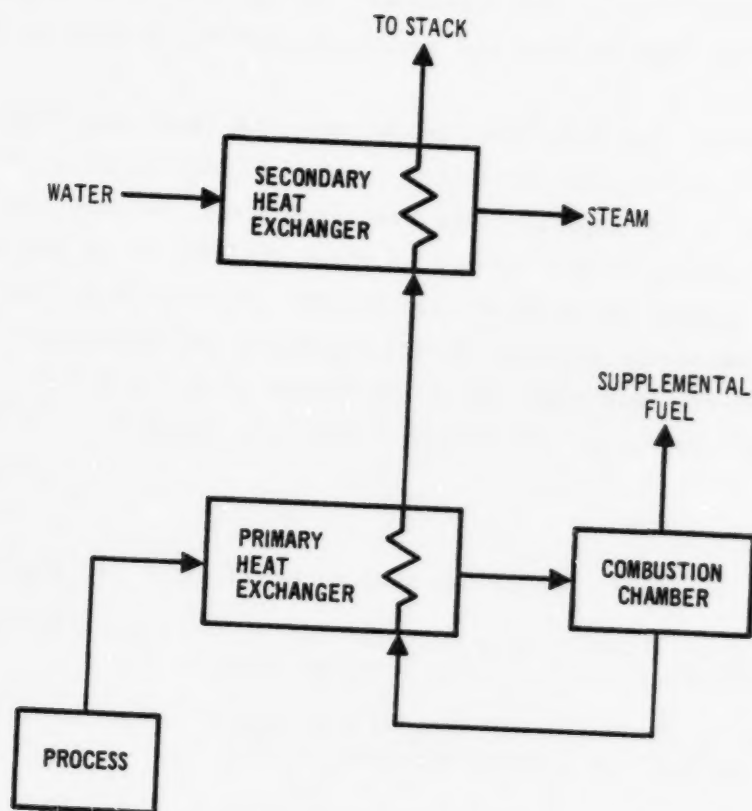
* The steam credit is a product of calculating the cost of steam (based on fossil fuel combustion) times the quantity of steam produced by a CO boiler.

FIGURE B-1
SCHEMATIC OF INCINERATION SYSTEM
WITH PRIMARY HEAT RECOVERY



Source: PEDCO Environmental, Inc. June 1979. "Carbon Monoxide Control Costs for Selected Processes." Prepared for U.S. EPA.

FIGURE B-2
SCHEMATIC OF INCINERATION SYSTEM WITH PRIMARY
AND SECONDARY HEAT RECOVERY



Source: PEDCO Environmental, Inc. June 1979. "Carbon Monoxide Control Costs for Selected Processes." Prepared for U.S. EPA.

The application of secondary heat recovery by any process was based on engineering judgment concerning the off-stream characteristics and the utility of the steam output. Since secondary recovery produces a negative cost, it always is selected by the costing algorithm for those processes where it is an option. The possibility that actual units may not be appropriate for secondary recovery, as opposed to the "model" processes costed, implies that the credits calculated may be optimistic.

In the event that, say, half the credits were not technologically or economically feasible, the annualized costs presented in Section 4 are understated while the capital costs are overstated. Because the capital cost picture changes in the absence of steam utility, it is not necessarily the case that annual costs merely are halved. Rather, on a case-specific basis, a determination would be needed regarding the advantage of secondary versus primary recovery relative to the degree of steam needed. For the purpose of this analysis, 100 percent credit was assumed.

B.4 CO SOURCE GROWTH

Inclusion of growth in CO emission sources would serve two purposes:

- To add costs automatically incurred due to New Source Performance Standards (NSPS) to the baseline costs
- To identify the level and cost of new source control motivated by the ambient air quality standard for CO.

Towards these ends, an evaluation was made of the extent to which new source controls are mandated by air quality limitations for CO.

At present, two process categories have NSPS promulgated for CO: the catalytic cracker (petroleum refining) and the electric submerged arc furnace (ferroalloy production). The control technology for the catalytic cracker is a CO boiler. For a new source, this type of control would be used in the absence of the standard because its operation

provides a net credit due to steam generation and, thus, an economic benefit. Since economics, rather than emissions control, constitutes the prime motive for CO recovery, the costs are not attributed to NSPS. Moreover, even uncontrolled FCCU have negligible ambient impact (refer to Table B-2); it is improbable that any of the alternative standards would motivate more stringent control, or significant costs.

Ferroalloy furnaces do not employ end-of-pipe controls specifically for CO reduction. In open furnaces, the CO combusts as part of the process while, in semi-enclosed furnaces, flaring the exhaust gas to reduce visible emissions also reduces CO. For this reason, the NSPS for this process was not considered to incur cost. Further, since the NEDS screen did not capture any ferroalloy furnace, it appears logical to conclude that this process does not constitute a significant source of ambient impact. Accordingly, additional control or costs under any alternative standards are not likely.

Beyond NSPS, other processes and industries were examined. Since incorporation of growth would be made, analytically, on a model source basis, only five processes would exhibit potential impacts (see Table B-2) at uncontrolled levels, thus motivating controls and incurring costs.

However, an examination of the typical control measures for these processes revealed either of two practices:

- Use of secondary heat recovery (e.g., CO boilers) to capture CO as a fuel, or
- Use of incineration of hydrocarbons to reduce adequately CO emissions.

In either case, it would be inappropriate to assign the total costs or credits associated with these types of measures to the carbon monoxide standard. Moreover, because the total costs incurred by existing point

sources are relatively small,* the significance of a growth increment likely would be small as well. The analysis indicated, therefore, that the incorporation of growth would not have noticeable effects on the magnitude of the costs estimated for attaining CO standards. For this reason, especially, the cost analysis is confined to the existing base of stationary point sources.

* Vis-a-vis mobile source total costs.

REFERENCES FOR APPENDIX B

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